The CHILD'S WORLD

The World and Its Wonders

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THE WORLD and ITS WONDERS

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THE WORLD
and ITS WONDERS

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TO THE READER

ROCKETS AWAY! That is the call of the space age. There are man-made moons called satellites in the sky today and man has set them there. Today we dream of traveling to the far planets—and perhaps you will be one of the space explorers of the future who make that dream come true.

Once the thought of space exploration was only a fantastic dream. Yet for thousands of years, men have looked up at the sun and moon and stars and wondered about them. They asked questions and tried to find answers. You will find many of these answers in the pages of this book.

Men wondered about the great seas, too. Once they believed that dragons and other strange monsters lived in the depths of the oceans. Today we know there are no dragons. But there is still much for us to learn about the mysteries of the undersea world, and as we explore we are discovering exciting secrets.

Rivers and mountains, air currents and sound waves hold exciting secrets, too. The wind and rain and weather affect the way we live and how we live. There is much to find out and know and scientists of many kinds are working to give us this knowledge.

The world of science is wide and wonderful. When you watch television or put on a plastic raincoat, you are using products of scientific discovery. When you ride in an elevator or cross a bridge or drive in a car along a highway, you are using the result of a scientific experiment, too.

Perhaps one of the most wonderful things about science is that every scientific discovery started in exactly the same way. Someone asked a question. Why does this happen? How can I make that happen? Then the scientist tested and experimented until he found the answer.

You, too, can be part of the world of science. When you are puzzled, you can ask a question. And you can search until you find the answer. It is exciting to explore the world of space. It is even more exciting to explore the world of knowledge.

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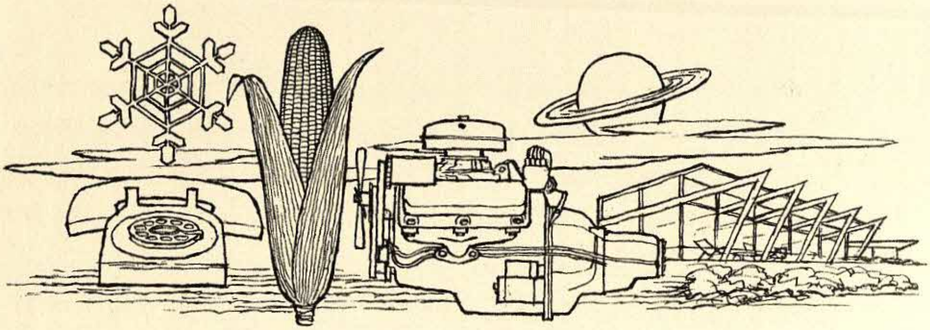

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MAURICE FRIEDLANDER

Ages ago, men did not know much about the earth nor the heavens above. So they imagined many things. They talked about the sun, the moon, and the stars as if they were people. Fearing and worshiping them as gods they made up stories about them. These have come down to us as legends.

Wise men, through the ages, were not content to guess. They studied the stars to find out how to explain their place in the heavens. They kept records of their observations. After the invention of the telescope, star-gazers like Galileo became certain that the earth was only one small part in a vast universe. In this picture, the earth has the most prominent place because it appears in the foreground. And so it is, to us who live on this planet.

Scientists have been unraveling a true story of the heavens that has more adventure, beauty, and wonder than any woven by the old legend makers.

THE EARTH AND SKY

WHIRLING IN SPACE

WE NEVER are still. Every minute of our lives we are on the go. Even while lifting a glass of water from the table to our lips we travel 30 or 40 miles. The earth and everything on it moves 18½ miles each second of the day and of the night as the earth travels through space in its orbit or circle-like journey around the sun.

We always are moving from west to east, too, because the earth turns completely around on its own axis every 24 hours. This double movement is much like that of a top that is spinning and at the same time making a wide sweep around the room.

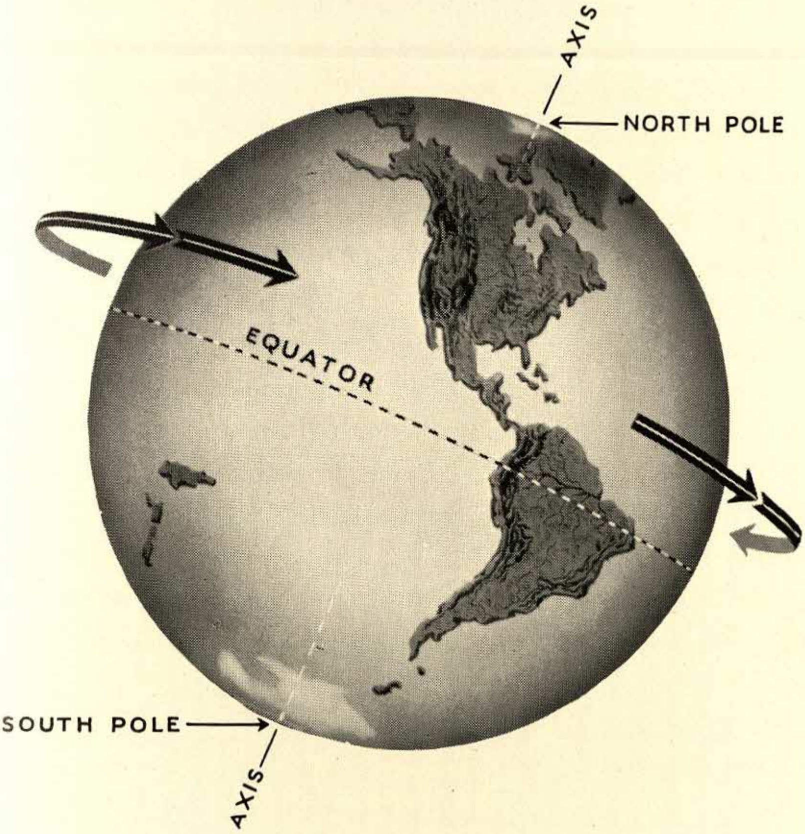
You may wonder at the thought of this earth of ours moving in these different ways and at such speeds. But this has been going on for many millions of years before you were born and will no doubt continue for as many more millions of years in the future. We cannot see or feel these motions of the earth, although we do see and feel the effects of them. We know, too, that the earth like everything else in the universe follows an orderly pattern. We can go to bed in the darkest night, feeling sure that there will be daylight at a certain time in the morning. We know that spring follows winter and summer follows spring. The reasons why these things occur as they do are more interesting than a fairy tale.

You may wonder, too, why we do not fall off the earth while we are traveling at such speeds. We surely would if something did not hold us on. This something is called the force or pull of gravity. We cannot see gravity but we know that it exists. Every time we throw a ball into the air it comes back down to us. We cannot stay up in the air without a support under us because gravity pulls us down, just as though a magnet were in the center of the earth drawing us toward it. It is the pull of gravity that gives us weight.

A long time ago people believed the earth was flat. They thought that if a ship sailed out to sea far enough, it would go over the edge of the world, fall off into space, and be lost forever. They thought the earth was the center of the universe and that the sun, moon, and stars moved around it. They felt certain of this because they could see that the heavenly bodies moved across the sky.

As time went on there were men who were not satisfied with these explanations. Some began to think that the earth was round like a ball. But until Christopher Columbus came along no one had the courage to sail across the ocean to try to prove it. And while he did not exactly prove that the earth is round, he convinced others who soon did prove it.

Map of known WORLD at the time of Columbus



WESTERN HEMISPHERE showing EARTH'S equator, poles, axis, and direction of turning

Later, men learned that the earth itself turns around every 24 hours and that it is one of several planets that revolve around the sun. Then it was possible to explain a great many things that never could be understood before, such as what happened to the sun at night. It was the turning of the earth that made the sun and the other heavenly bodies *seem to move* across the sky.

It is easy to see why people used to think the earth was flat. It looks that way because we can see only a small part of it at one time. The land and the water curve slightly. Thus if we were to keep going mile after mile in the same direction we would come back to the place from where we had started. In the days of sailing vessels, it was a long hard journey to prove this, but today airplanes regularly "circle" nearly all parts of the globe.

Suppose we let an orange represent the earth. Then, let us insert a small stick part way into the top of the orange and another into the bottom exactly opposite the first one. The spot where the top stick enters the orange is called the North Pole, and the bottom stick marks the South Pole. Imagine a line running straight through the center of the earth between these two places. This line is called the earth's axis. Imagine another line running around the outside of the orange at its center, halfway between the two poles. This is called the earth's Equator.

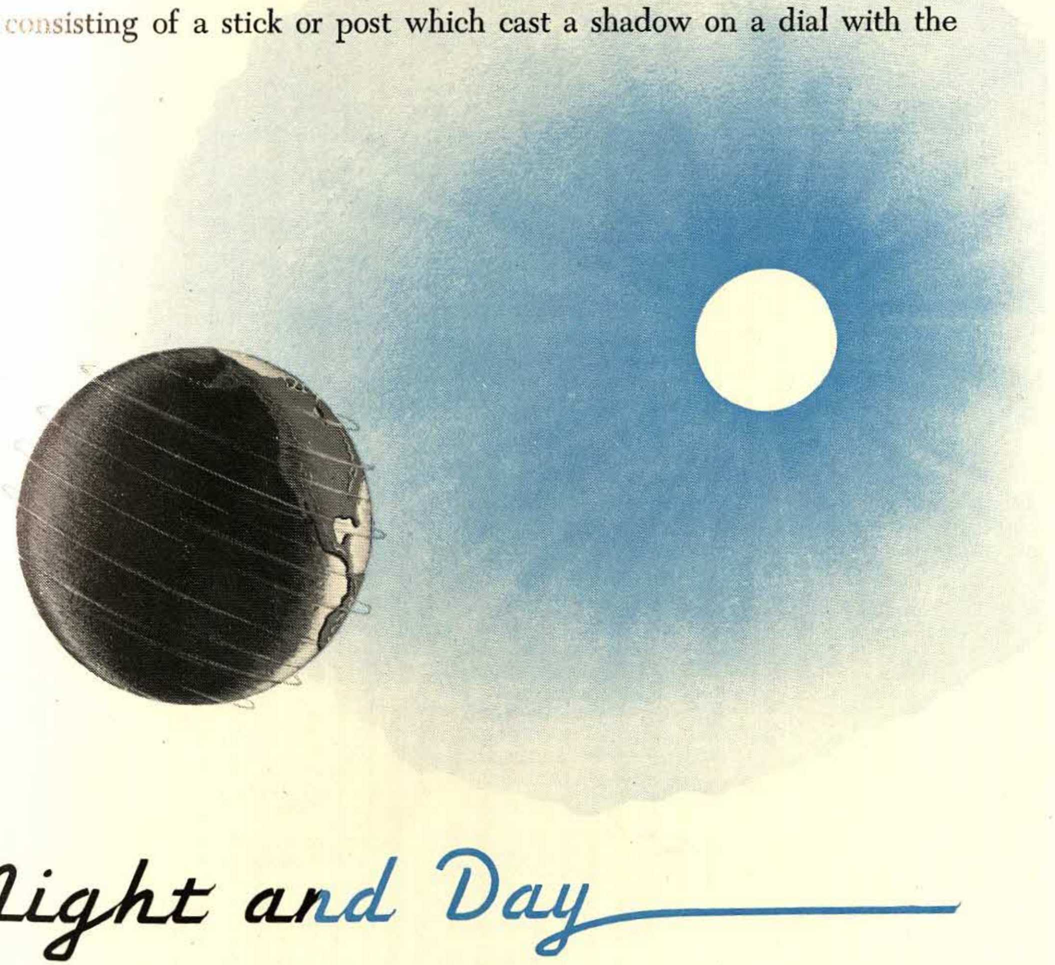
The diameter of the earth, that is, the distance straight through its center at the Equator is 7,927 miles. The length of its axis is 27 miles less showing that the earth is just slightly flattened at the poles. The earth's circumference, or the distance around it, at the Equator, is 24,902 miles. On some maps the earth is divided into halves, or hemispheres. Thus we speak of the Northern Hemisphere and the Southern Hemisphere or the Eastern and Western Hemispheres, depending on which way we divide it. North and South America belong in what is considered the Western Hemisphere.

Taking one of the sticks in the fingers of each hand, turn the orange slowly to the left. The earth is now turning on its axis. You can easily see that it is moving much more rapidly at the Equator than near the poles. In fact, at the Equator the earth turns at the rate of about 17 miles a minute, while in Chicago, 3,000 miles north of the Equator, or Wellington, New Zealand, 3,000 miles south, it turns at the rate of only 12 miles a minute.

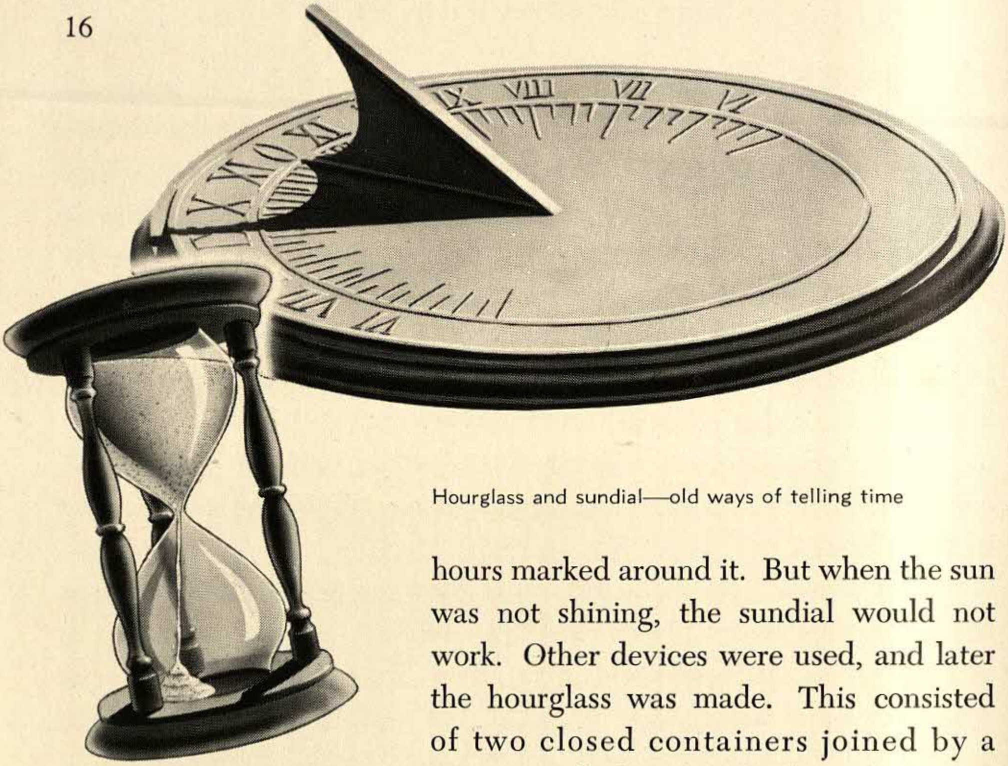
Now, suppose you mark a tiny spot on the orange to show about where you live. Never mind if you do not get it just right because almost any spot will do. With a small light, such as a candle or a flashlight, in a darkened room you can see the appearance of day and night quite clearly as you turn the orange, or earth, on its axis. When your spot on the earth is toward the candle which, of course, we are pretending is the sun, you are in the light and it is day, and when it is on the opposite side, you are in the dark and it is night. Do you understand why the sun comes up on the side toward which the earth is turning and goes across the sky to the west, and at night the stars move across in the same direction? You can see now that it is the earth's turning which makes it look as though the sun and stars were moving.

As the earth spins around from west to east the side that is toward the sun is constantly changing. The sun "rises," that is, daylight comes when the earth has rotated on its axis far enough to bring us within the light of the sun. As we turn farther eastward the sun seems to climb in the sky until it seems nearly overhead. At that point we say it is noon. Noon comes at the exact moment when the sun appears to pass from the eastern to the western half of the sky. As the earth continues to revolve the spot on which we live begins to turn away from the sun. This causes the sun to appear to sink lower and lower in the western sky until it finally "sets." Then night begins. It will continue until the earth turns around far enough for the sun's rays to strike us again.

Before clocks were invented, men experimented until they found ways of telling time. They noticed the different positions and lengths of shadows at different times of the day. They invented the sundial consisting of a stick or post which cast a shadow on a dial with the



Night and Day

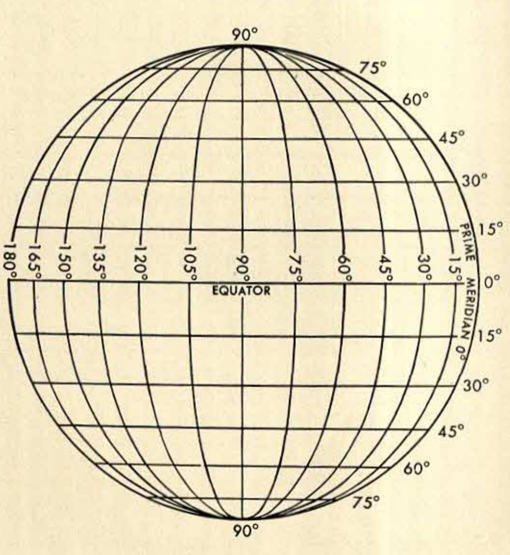


Hourglass and sundial—old ways of telling time

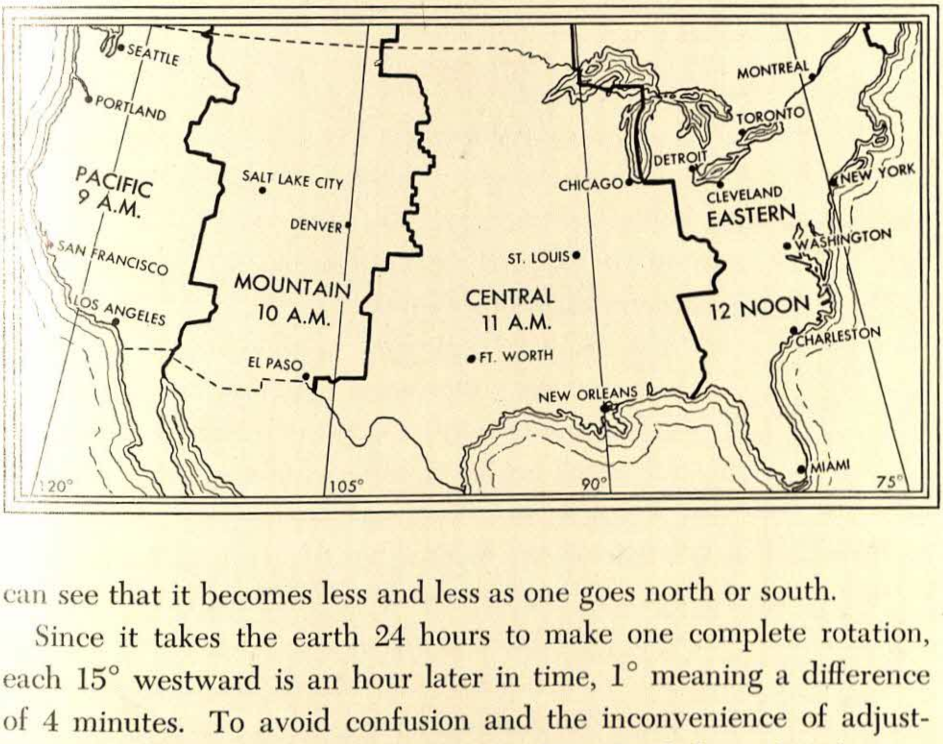
hours marked around it. But when the sun was not shining, the sundial would not work. Other devices were used, and later the hourglass was made. This consisted of two closed containers joined by a narrow neck through which sand or some other substance slowly poured. Just enough of this material was put in so that it would take an hour for it to run from one container to the other. When it had all run out, the hourglass was turned over so that it would run back again during the next hour.

The correct time that we hear over the radio every day is based on signals sent out by the United States Naval Observatory, where it is obtained by checking the position of the earth in relation to the stars. Our watches may stop, or lose or gain a little, but the turning of the earth is always exactly on time. It is from the speed of its turning that our time is reckoned.

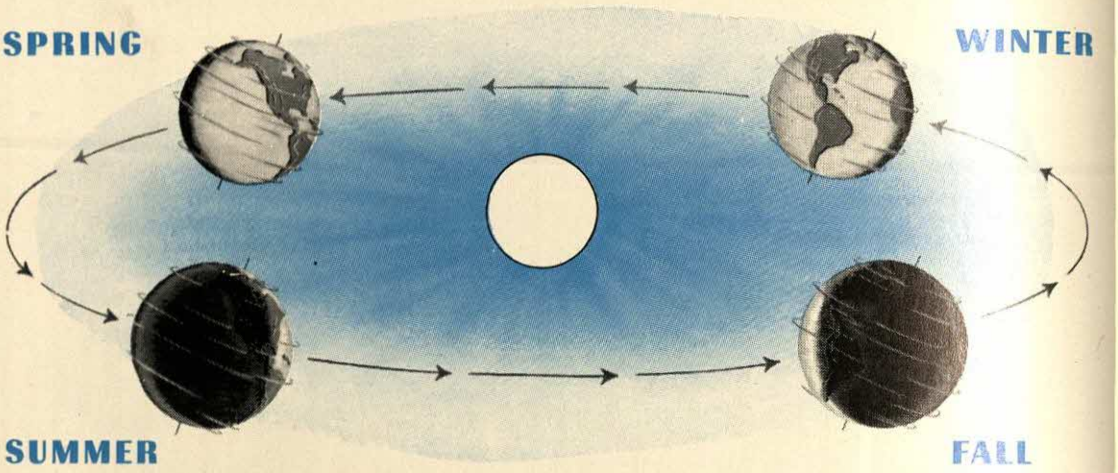
As a circle is divided into 360 equal parts, or degrees, the distance around the



Meridians and parallels at 15° intervals earth's surface is for many purposes expressed in degrees. Degrees of a circle, like degrees of temperature, are usually written by a symbol that looks like a small zero after the number. Thus 90 degrees is written 90°. The accepted starting point for measuring distances east and west, called longitude, and also for reckoning time is the *prime* meridian, a half circle between the poles running through Greenwich, England. In the same way distances north or south, with the Equator as the dividing line, are measured in degrees of latitude. While a degree of longitude is about 70 miles at the Equator you can see that it becomes less and less as one goes north or south.



Since it takes the earth 24 hours to make one complete rotation, each 15° westward is an hour later in time, 1° meaning a difference of 4 minutes. To avoid confusion and the inconvenience of adjusting timepieces more frequently, the world is divided into hourly time belts or zones about 15° wide. Thus, when we travel eastward or westward, we merely set our watches ahead or behind one hour at a time as we cross the line from one zone to another. There are four such zones in the United States—Eastern, Central, Mountain, and Pacific. When it is 12 o'clock noon in New York, many people in Los Angeles or San Francisco are having a late breakfast, for there it is only 9 o'clock.



JOURNEY AROUND THE SUN

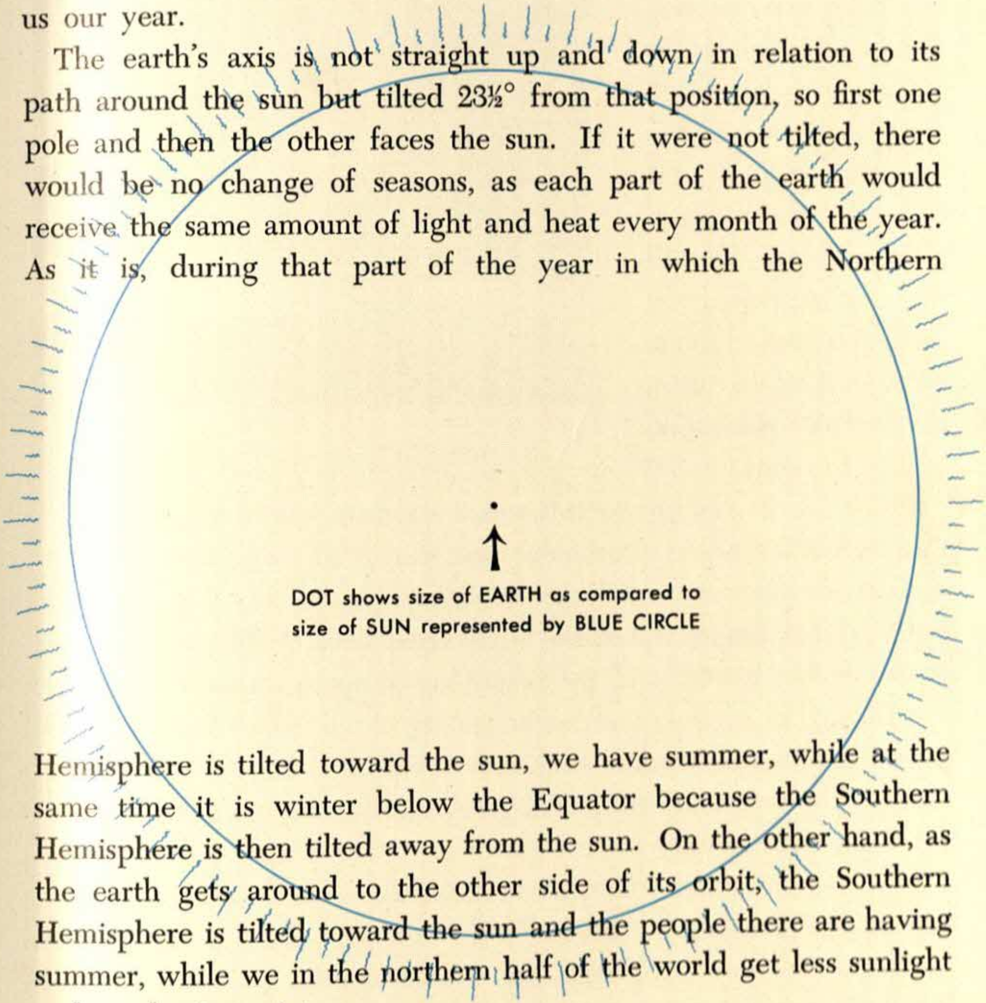
LONG ago people thought the sun was a god. They worshiped it because they knew it gave them light to see by and heat to warm their bodies and to ripen their crops. Today we know that the sun is a whirling, glowing ball of hot gases and that it is really a star, our day star. It is at the center of the vast orbits, or paths, in which the earth and the other planets travel through space.

In fact, the earth actually is controlled by the sun. Just as the earth's gravity holds everything on the earth to it, the force of gravity of the sun holds the earth in its path around the sun. It is the sun and not the earth that is the center of our part of the universe. And it is well for us that this is so. Without the sun, the earth would be a terribly cold, dark place. Nothing could grow on it. No one could live on it.

In comparison with the size of the sun, the earth is very small. In terms of diameters, it would take 109 of our earths in a row to extend across the diameter of the sun. But in terms of volume or total space occupied, it would take more than 1,000,000 globes the size of the earth to make a globe the size of the sun. It is the great distance from us that makes the sun look as small as it does. It is 93,000,000 miles away.

In the previous story we learned that the spinning of the earth on its axis brings us night and day. This story will tell more about the other important motion of the earth, its long journey around the sun. It is this movement that brings us our seasons—spring, summer, autumn or fall as it is commonly called, and winter. It takes the earth 365¼ days to make the complete trip and this gives us our year.

The earth's axis is not straight up and down in relation to its path around the sun but tilted 23½° from that position, so first one pole and then the other faces the sun. If it were not tilted, there would be no change of seasons, as each part of the earth would receive the same amount of light and heat every month of the year. As it is, during that part of the year in which the Northern Hemisphere is tilted toward the sun, we have summer, while at the same time it is winter below the Equator because the Southern Hemisphere is then tilted away from the sun. On the other hand, as the earth gets around to the other side of its orbit, the Southern Hemisphere is tilted toward the sun and the people there are having summer, while we in the northern half of the world get less sunlight and are having winter.



DOT shows size of EARTH as compared to size of SUN represented by BLUE CIRCLE

Suppose you use the orange for the earth with the sticks placed at the poles again and let a grapefruit represent the sun. Have someone hold the grapefruit in his outstretched hand. With the orange tilted as in the picture on the opposite page, turn it on its axis, and at the same time move it slowly in a wide circular sweep around the grapefruit.

Remember always to keep the sticks in the orange pointing in the same direction, just as the earth's axis is always in line with the North Star, regardless of the motion of the earth. You are showing the journey the earth makes every year. When you have gone around once and reached the point you started from, a year has passed. Notice that part of the time the North Pole is more directly toward the sun but when the earth gets around to the other side of its orbit, the South Pole is tipped toward the sun.

WINTER brings snow and cold

There are two points in this yearly journey where the two hemispheres get an equal amount of sunshine, with neither pole pointing toward the sun more than the other. At these points, it is the Equator that exactly faces the sun. These two times each year are at the end of winter and the beginning of spring, about March 21; and the end of summer and the beginning of fall, about September 23. On these occasions day and night are equal, each being 12 hours long, all over the world. Then for all points on the Equator, at noon the sun is directly overhead.

When the Northern Hemisphere is turned toward the sun, more of this half of the world is in daylight. Our days then are longer and the nights shorter. The opposite is true at this same time in the Southern Hemisphere, just as our nights are longer and our days are shorter in winter. And we not only have less hours of daylight in winter but, when the earth is tilted away from the sun, the rays strike us at more of a slant, so they give us less heat.

You know how much lower the sun appears in the sky in winter than in summer and how much less warmth the sun has then. Likewise the sun's rays are not nearly as hot in the early morning or late afternoon as they are when the sun is nearly overhead. These slanting rays do not warm us so much because as they strike the earth they spread out over a wider area and have less effect on any one spot.

SUMMER brings grass and flowers

You can see how this is when on a dark night you point a flashlight straight at your feet. You then get a bright light on a small spot; but if you tilt the light in order to cover 30 or 40 feet of the pathway ahead of you, no spot gets much light because the same amount of light is spread over more space.

The sun is not only exactly overhead at the Equator twice each year but, near the Equator, the noonday sun is never far from overhead. There the days and nights are never far from equal in length regardless of what the seasons may be farther north or south. Thus the temperature is much the same there the year around. It is always hot summer weather.

As we go north or south away from the Equator, the weather varies. There is winter and summer. When it is winter in the Northern Hemisphere, a large area around the North Pole cannot possibly get any sunlight, regardless of the spinning of the earth, because it is turned away from the sun. There are several months when that part of the earth does not have any daylight at all. At the same time a similar area around the South Pole is having constant daylight with no night. When the earth gets around to the opposite side of its orbit, those conditions are reversed. Thus the winters in the Far North or the Far South are not only very cold, but they also are in continual darkness. Those same places in summer are in constant daylight but, as the sun's rays even then are quite slanting, the polar regions never receive a great deal of heat.

Thus we see that the earth's journey around the sun brings the changes of season to the different parts of the earth, and that some parts of it are affected much more than others.

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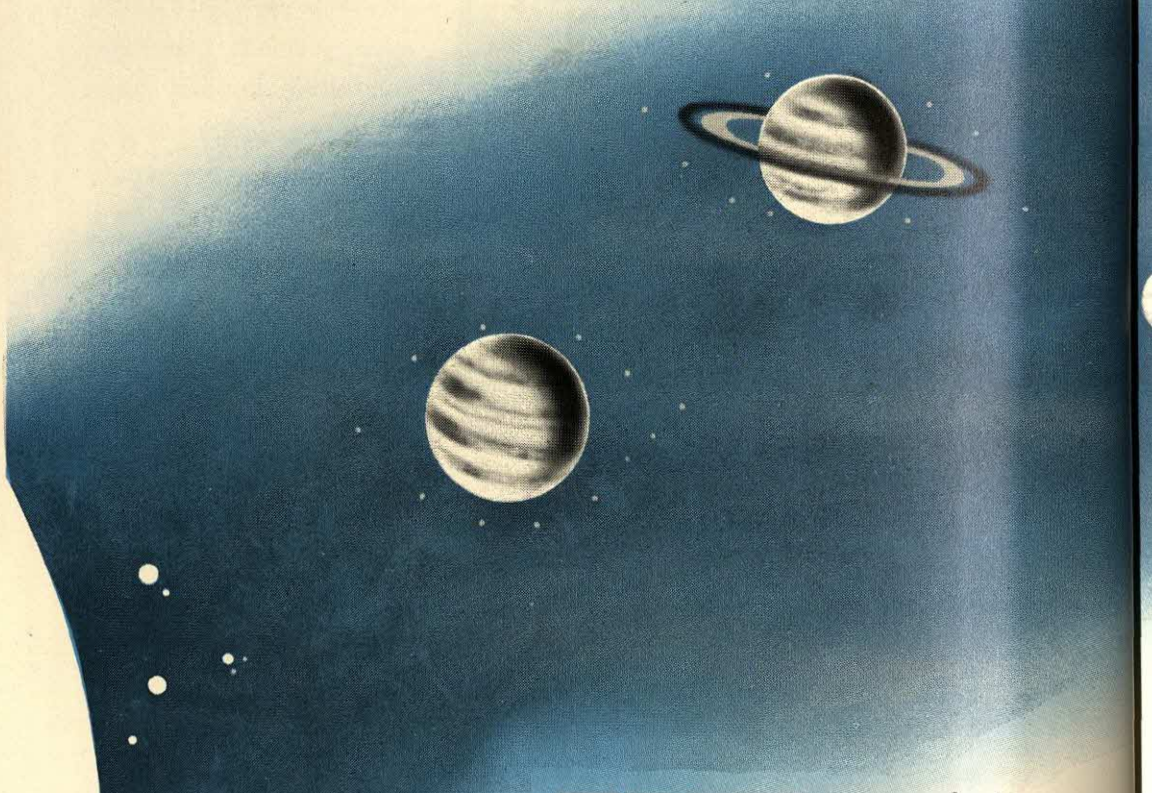
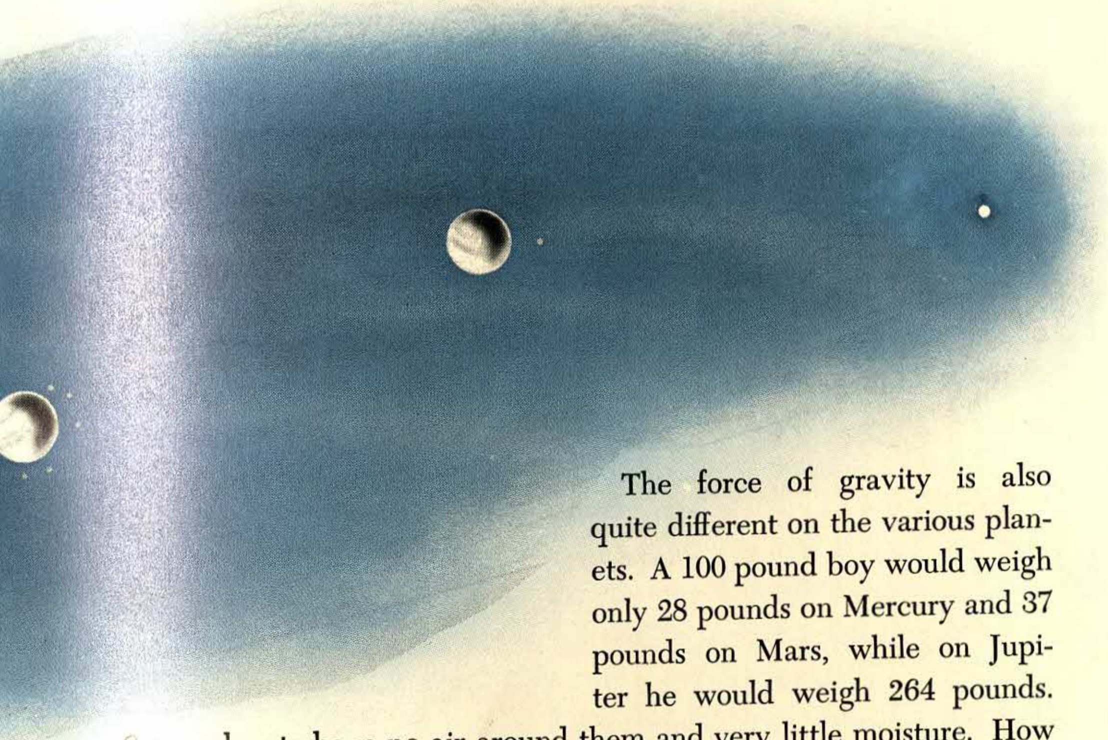
THE EARTH'S BROTHER PLANETS



THE EARTH is one of nine planets. Like the other eight, it is controlled by the sun and revolves about it. All the planets move in the same direction, but each at a different distance from the sun. And, although they are said to belong to the same family and act alike in many ways, they are quite different in others, just as brothers often are.

Some planets, since they are closer to the sun than others, are very hot while those far away are very cold. Some are smaller than the earth and some are much larger. As the length of a day on any planet is the time that it takes to rotate once on its axis and the length of a year is the time that it takes to revolve once in its orbit around the sun, all have days and years of different lengths.



The force of gravity is also quite different on the various planets. A 100 pound boy would weigh only 28 pounds on Mercury and 37 pounds on Mars, while on Jupiter he would weigh 264 pounds. Some planets have no air around them and very little moisture. How many problems we would have if the dream of some people should come true—that one day we might step into a fast rocket ship and visit another planet!

In the picture above only a very small part of one edge of the sun could be shown because it is so much larger than the planets. And to show the planets in order and in their relative sizes a little space had to represent enormous distances.

The smallest planet is Mercury, just a little larger than our moon. It is also the planet nearest to the sun. Being the nearest, Mercury has the shortest journey around the sun; also its speed is the greatest. And, of course, it is the hottest, at least it has the hottest day. As compared with our year of 365 days, it takes Mercury only 88 days to make one complete trip around the sun. But Mercury turns only once on its axis during its entire year thus keeping the same side to the sun just as our moon does to the earth. Therefore the side that is away from the sun, or night side, never gets any daylight at all and is, no doubt, extremely cold. When Mercury can be seen, which is not often because it is so near the sun, it appears in the western sky right after sunset or in the eastern sky just before sunrise. It then looks as bright as a star.

Next to Mercury comes Venus, about twice as far from the sun. Venus is almost as large as the earth. Its orbit is closer to the earth's than that of any other planet. No other planet ever appears so bright to us as Venus does at certain periods. It often can be seen in the evening right after sundown when it is sometimes called the evening star, or just before sunrise when it is then frequently referred to as the morning star. On Venus a year is 7½ months long. Astronomers believe that its day is about a month long, that is, it takes one of our months for Venus to turn once around on its axis. Thus Venus, also, would have only 7½ days to its year.

Next comes our earth, then Mars. Since Mars is farther out, its orbit is larger so it takes almost twice as long to go around the sun as the earth takes, and almost 8 times as long as for Mercury. Scientists doubt that there is life on any other planet besides our own, but if there is, it is probably on Mars. It is not as warm on Mars as on the earth and the nights and winters must be exceedingly cold; moreover, the atmosphere there is known to contain very little, if any, oxygen or moisture. The day on Mars is about the length of ours. Mars has two tiny moons, about 5 or 10 miles in diameter, going around it much as our moon goes around the earth.

The next planet, Jupiter, is more than 3 times as far from the sun as Mars. We are getting into really huge distances now and also we are dealing with a much larger planet. Jupiter is larger than all the other planets put together. It takes 12 years for Jupiter to go around the sun but it spins more rapidly on its axis so it has a shorter day than any of the other planets. Jupiter has at least 12 moons, 4 of them as large or larger than our own.

Saturn is nearly as large as Jupiter and almost twice as far from the sun. Through a telescope Saturn is seen to have 9 large moons and several rings around it, which are made up of thousands of tiny bodies or meteors.

Then comes Uranus with its 5 moons, nearly twice as far from the sun as Saturn. Still farther away is Neptune. It can never be seen with the naked eye. The temperature must be very low there for Neptune is 30 times as far away from the sun as the earth.

Pluto is so far away that even with the most powerful telescope it was undiscovered until 1930. Not much is known about it yet except that it takes about 250 years to make one trip around the sun, and that its diameter is a little less than half that of the earth.

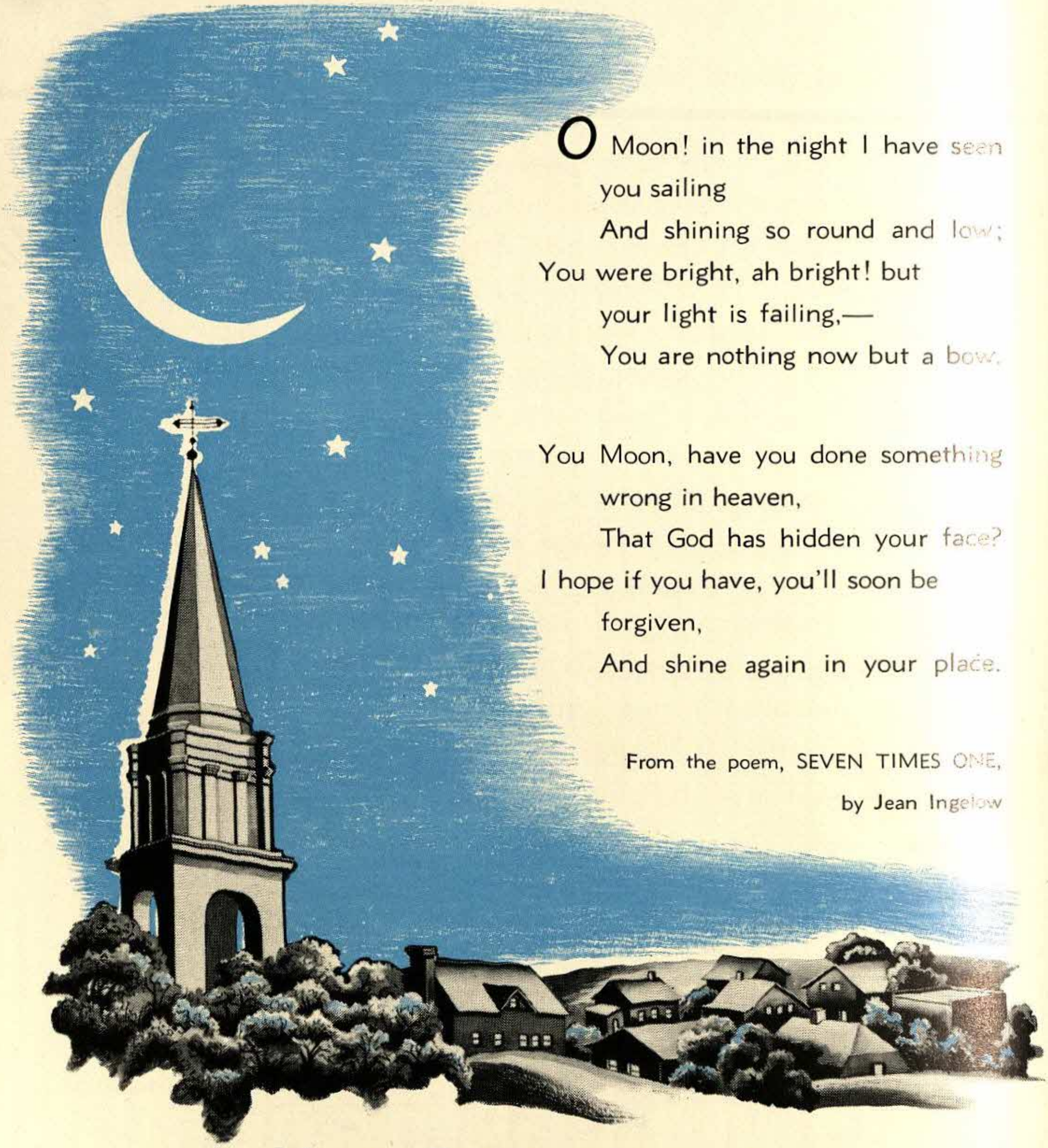
The word planet means "wanderer" and it might seem at first, as it did to the ancient Greeks who gave them the name, that they wander about in space. In order to get all of the planets in a picture in something like their proper relationship, they all had to be shown on the same side of the sun. Rarely would they all arrive on the same side at any one time since they all travel at different speeds and have different distances to go in their journeys around the sun.

Like the moon, we can see only that part of any planet that is in a position to reflect sunlight toward us, since the planets have no light of their own. Also, they appear brighter or dimmer as they get closer to the earth or farther away in their wide sweeps around the sun. No wonder the ancients thought they were wanderers.

You can usually tell a planet from a star because the planets do not seem to twinkle as the stars do.

FACTS ABOUT THE PLANETS

PLANET	DIAMETER (in miles)	DISTANCE FROM SUN (in millions of miles)	LENGTH OF DAY (time required to rotate once on its axis)	LENGTH OF YEAR (time required to revolve around sun)
Mercury	3,100	36	88 days	88 days
Venus	7,700	67	about 1 month	225 days
Earth	7,927	93	1 day (24 hours)	365¼ days
Mars	4,221	141	24 hours 37 minutes	1 year & 322 days
Jupiter	86,850	483	9 hours 50 minutes	11.86 years
Saturn	71,600	886	10 hours 14 minutes	29½ years
Uranus	32,000	1,782	10 hours 45 minutes	84 years
Neptune	31,000	2,793	15 hours 48 minutes	165 years
Pluto	3,550	3,670	(?)	248 years



O Moon! in the night I have seen
you sailing
And shining so round and low;
You were bright, ah bright! but
your light is failing,—
You are nothing now but a bow.

You Moon, have you done something
wrong in heaven,
That God has hidden your face?
I hope if you have, you'll soon be
forgiven,
And shine again in your place.

From the poem, SEVEN TIMES ONE,
by Jean Ingelow

NIGHT RIDER OF THE SKY

PERHAPS more poems and stories and songs have been written about the moon than about any other heavenly body. From the earliest times people have had a great interest in it.

If we look at the moon through a telescope, we see that the surface is very rough and uneven like much of the earth, with high mountains or dead volcanoes. In many places there are enormous craters somewhat like the holes you make when you throw stones in soft mud.

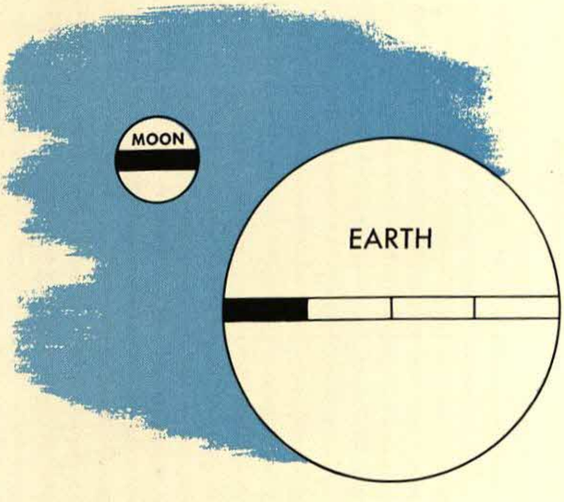
The moon has broad plains, too, which appear to us as darker patches. It is these plains that we imagine make up the face of the "man in the moon." If people lived on the moon and looked on our earth they undoubtedly would see pictures on it too. We often can see the moon in the daytime, although very faintly because the sky is then so bright. But whether we see it or not, it always has some effect on the earth. Its force of gravity exerts enough pull on the water of the ocean so that the moon is the chief cause of our tides.

The moon is much nearer to the earth than any other heavenly body and, except for the sun, it is the brightest. It is ruled by the earth and compelled by the earth's pull of gravity to go around it just as the earth is controlled by the sun and compelled to go in a wide circle-like sweep around the sun.

The moon is only about 240,000 miles away from us and while this is nearly as far as 10 times around our Equator, it is very little compared to the enormous distances between the planets and the sun and the stars. The sun is about 400 times as far from us.

The diameter of the moon is only 2,160 miles, about ¼ that of the earth, but because they are both in the shape of a ball, it would take about 50 moons to fill a globe the size of the earth. The reason why the moon looks about as large as the sun is that the moon is so very much closer to us.

The force of gravity of the moon is only ⅙ that of the earth, so a man weighing 180 pounds on the earth would weigh only 30 pounds there. However, we may be sure that no one lives on the moon as the conditions are such that no kind of life, either plant or animal as we know it, could possibly exist. There is practically no air or moisture, therefore there can be no clouds or winds, nothing to tone down the blinding sunshine of days that are two weeks long.



And the equally long nights must be very dark and intensely cold.

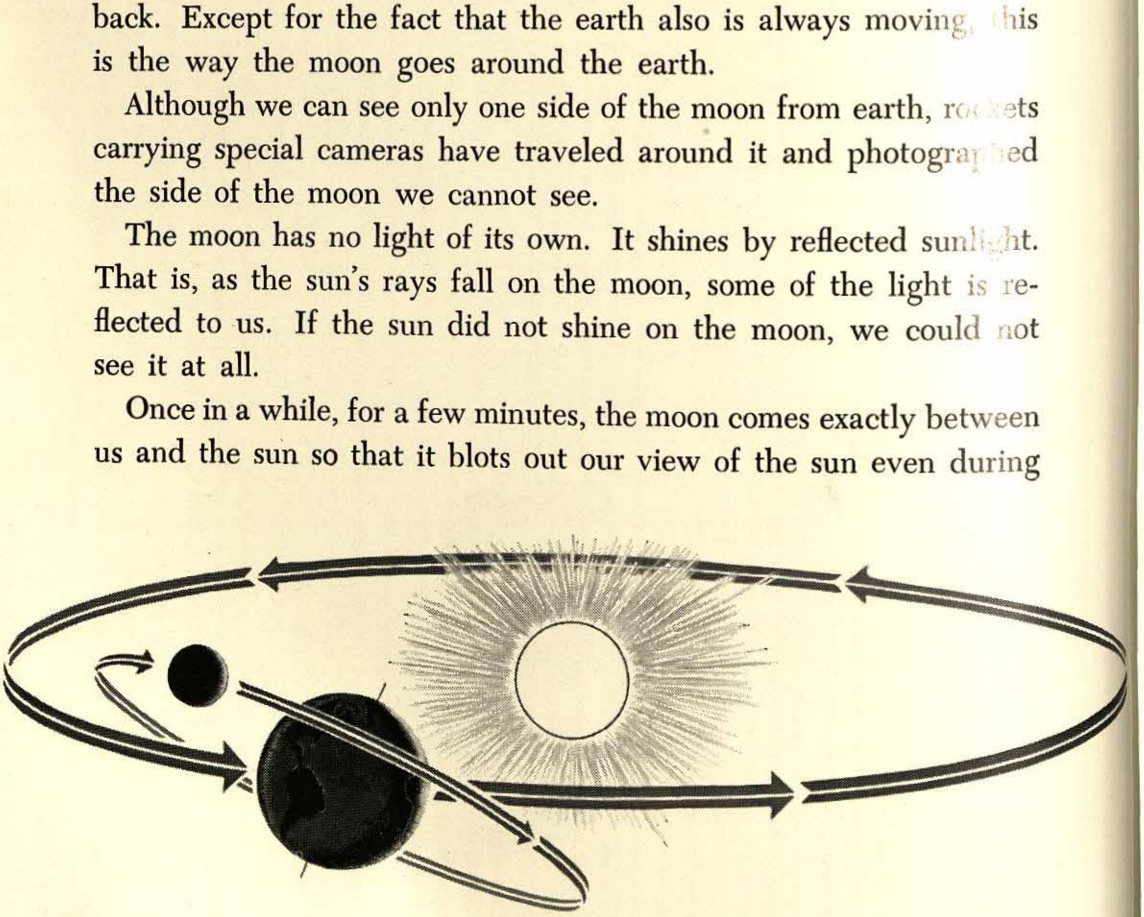
As our earth is turning on its axis and at the same time making its long yearly journey around the sun, the moon is turning on its own axis and also traveling in a path around the earth. The earth, you know, turns 365¼ times while it is making the trip around the sun. The moon makes just *one* turn on its axis during the 27⅓ days that it takes to go around the earth. Therefore, it always keeps the same side toward the earth.

Suppose you put a chair in the center of the room to represent the earth. Then pretend you are the moon and, walking sideways, step around the chair always facing toward it until you have gone once around. By so doing, you have slowly turned once at the same time that you were going around the chair, although your face was always toward the chair. A person sitting in the chair could not see your back. Except for the fact that the earth also is always moving, this is the way the moon goes around the earth.

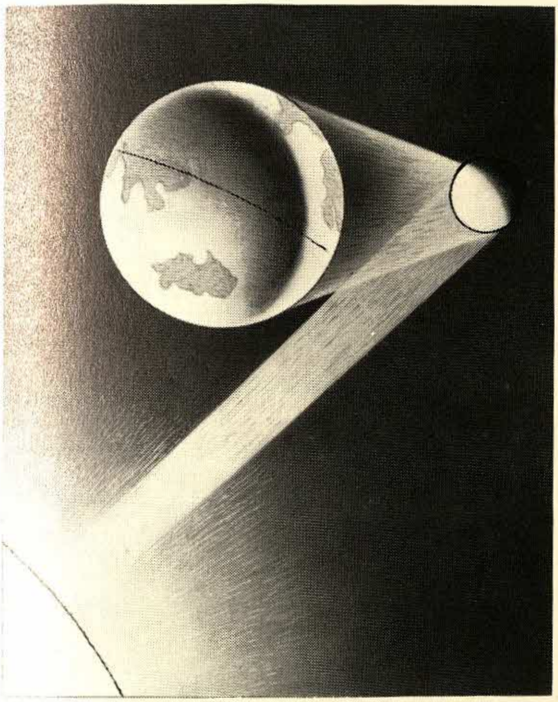
Although we can see only one side of the moon from earth, rockets carrying special cameras have traveled around it and photographed the side of the moon we cannot see.

The moon has no light of its own. It shines by reflected sunlight. That is, as the sun's rays fall on the moon, some of the light is reflected to us. If the sun did not shine on the moon, we could not see it at all.

Once in a while, for a few minutes, the moon comes exactly between us and the sun so that it blots out our view of the sun even during



The MOON revolves around the EARTH while the EARTH revolves around the SUN



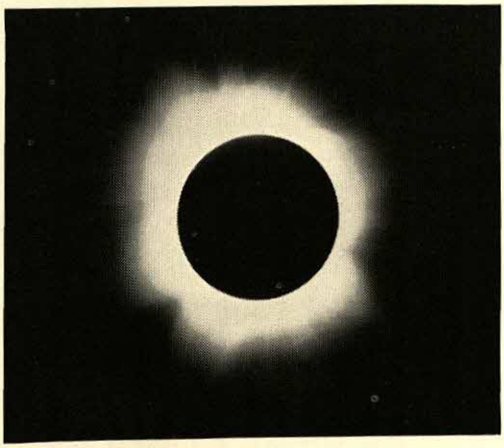
the day. Then the earth gets as dark as it does on a cloudy day. This is called an eclipse of the sun.

Sometimes, too, the moon happens to get on the opposite side of our planet so that the earth blocks the sun's rays to the moon. That is, the moon gets in the earth's shadow. We call this an eclipse of the moon and it may last for several hours.

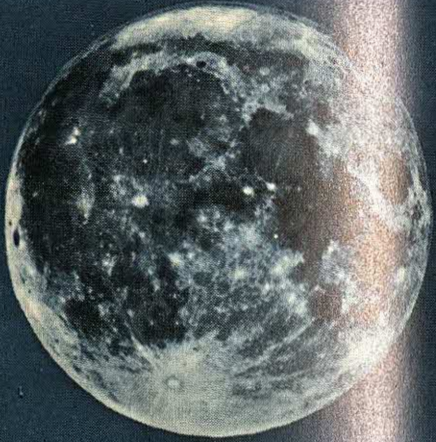
You know that the sun shines on only half of the earth at one time. It also shines on only half of the moon, but from where we are, we cannot always see all of the section that is lighted. When the moon is almost in line with the sun, we cannot see it at all. The moon is then said to be new.

About 2 days later as the moon moves over slightly to one side there is a tiny strip along the edge toward the sun that shows to us. The moon then, still quite new, appears faintly as a thin crescent in the western sky just after the sun has gone down.

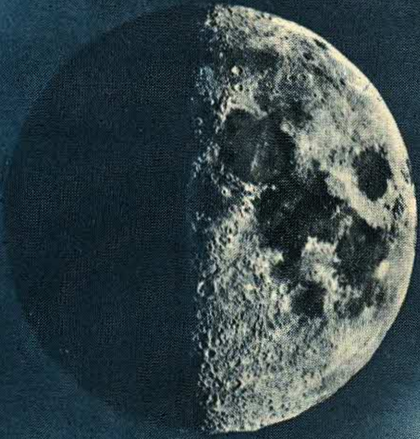
Each night the moon appears almost an hour later. As it moves over farther from the sun, more of the side that is in sunlight can be seen so that its crescent



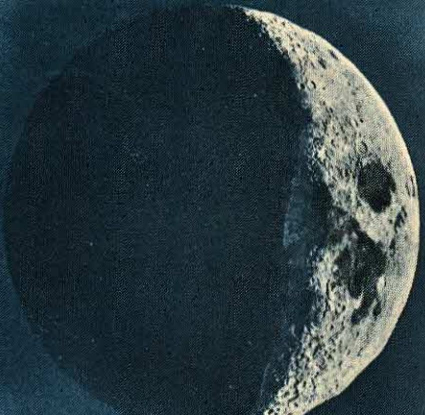
Eclipse of the SUN



14.9 DAYS



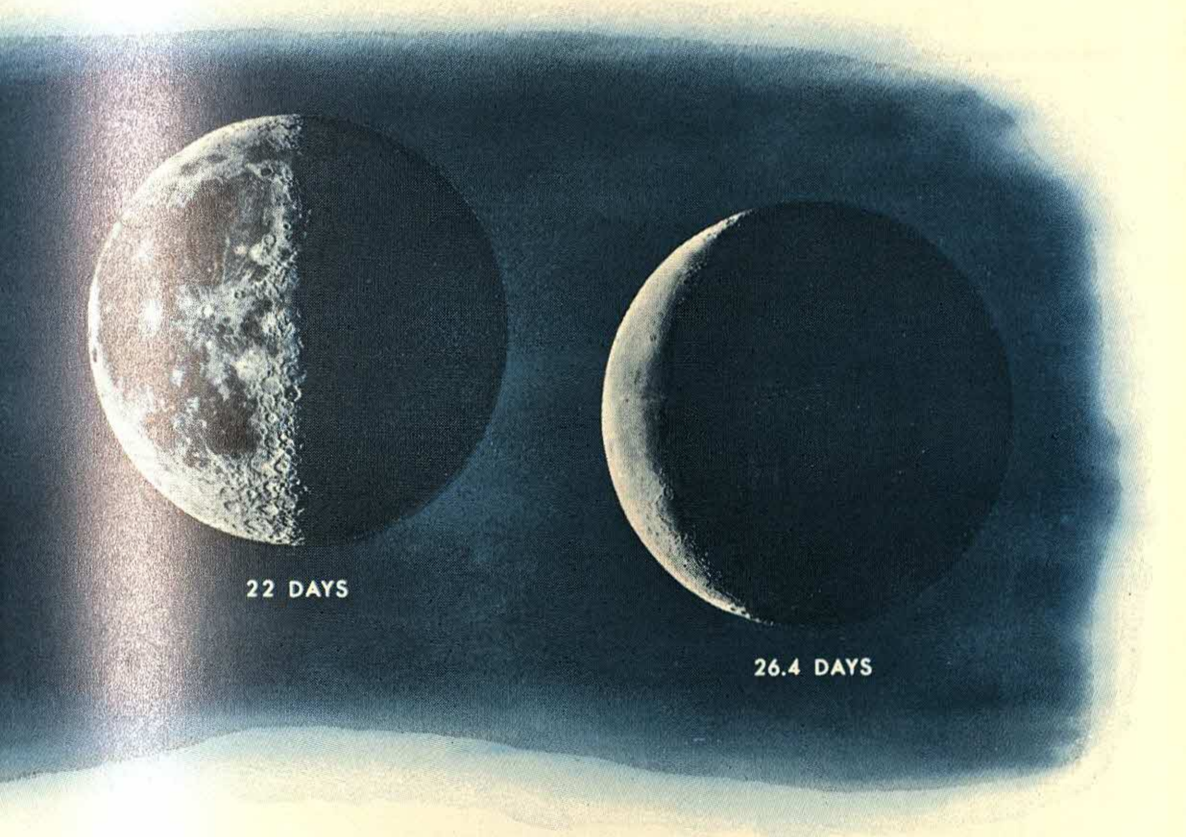
7 DAYS



4.6 DAYS

shape becomes wider and wider. About a week after new moon, the moon looks like a capital D and this appearance or phase is called the first quarter. It has now gone ¼ of the way around the earth.

This shape becomes still wider as the moon gets farther from the sun until in about another week, the moon is in the position opposite the sun where we can see the entire lighted side.



Then the side that is always toward the earth is also directly toward the sun. It looks big and round and bright and we call it a full moon. The moon has now gone ½ of the way around the earth.

In a few nights the light will not be so bright for the moon will begin to wane or grow thinner. In another week's time when it has gone ¾ of the way around the earth, we will see only ½ of its face again. This is called the last quarter moon and looks like the first quarter moon turned around. From then on the crescent becomes thinner and thinner until it fades completely from sight.

While it has taken the moon only 27⅓ days to go around the earth, the earth also has been moving in its orbit around the sun. It takes a little longer, 29½ days in all, for the moon to go far enough to arrive at the position nearly in line with the sun where it is ready to start on its phases again. Do you see why a month is often referred to as a "moon"?

TWINKLING FAR AWAY

THE STARS are other huge glowing balls like our sun. Many of them are much larger than the sun, and like it they give off light and heat. We can see their light but we cannot feel their warmth because they are so very far away from the earth.

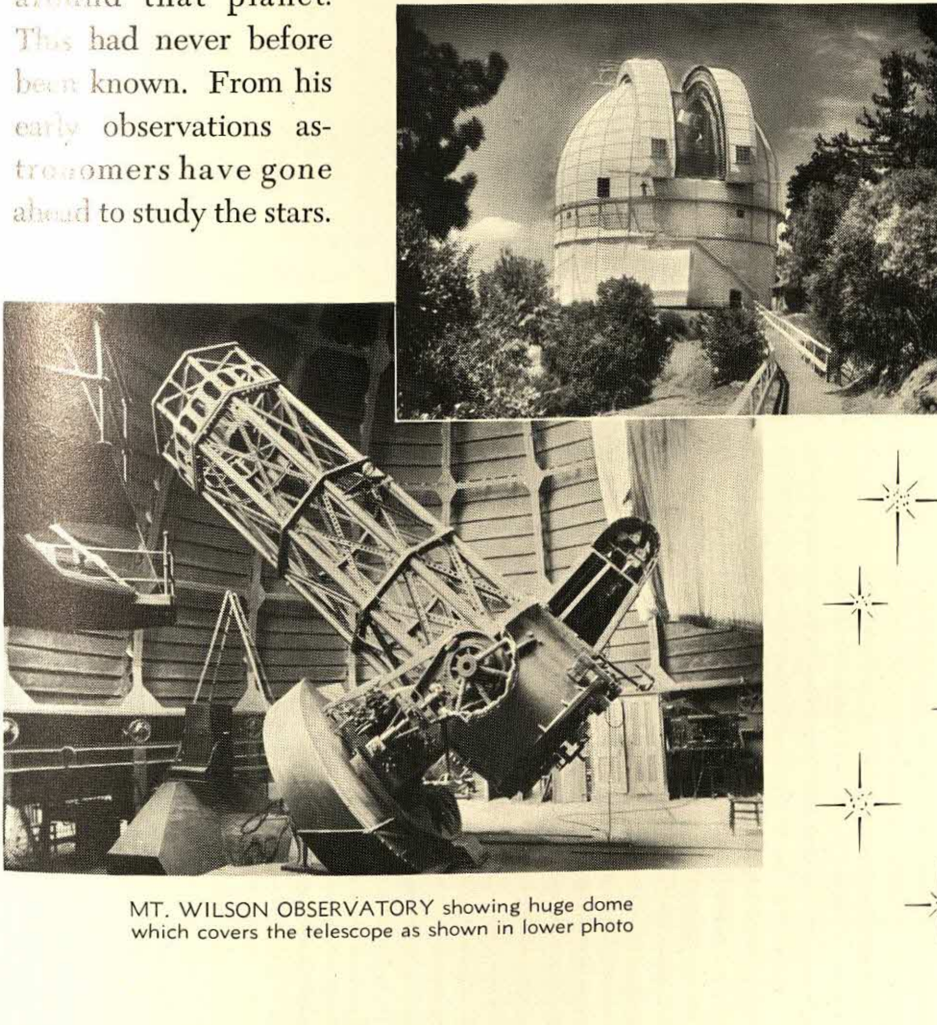
To get a better understanding of their enormous sizes and their distances from us, let us start with some of the things we have already learned. In the first story we used an orange to represent the earth. If we want to show the sun in its true size compared with the earth, we will have to let a two-car garage or something about that size represent the sun. And we will have to place the orange nearly ½ mile from the garage, so great is the distance of the earth from the sun. Our model, though, is already getting large and we have hardly started to measure the distance to the stars. Let us use some smaller objects for comparison.

Suppose we let a little pea represent the earth. Then we must use something very small, perhaps the head of a pin for the moon, and place it about 10 inches from the pea. But we will need a giant pumpkin nearly 3 feet across to represent the sun, and it must be placed about a block away. Now we can see how enormously larger and farther away the sun is, as compared to the moon.

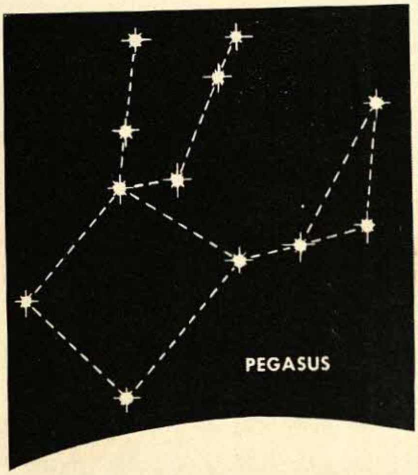
We could select other objects of appropriate sizes to represent the planets, perhaps an orange for Jupiter placed out about 5 blocks, and we might let another pea, if we can find a very small one, represent Pluto, but it would have to be placed 2½ miles away.

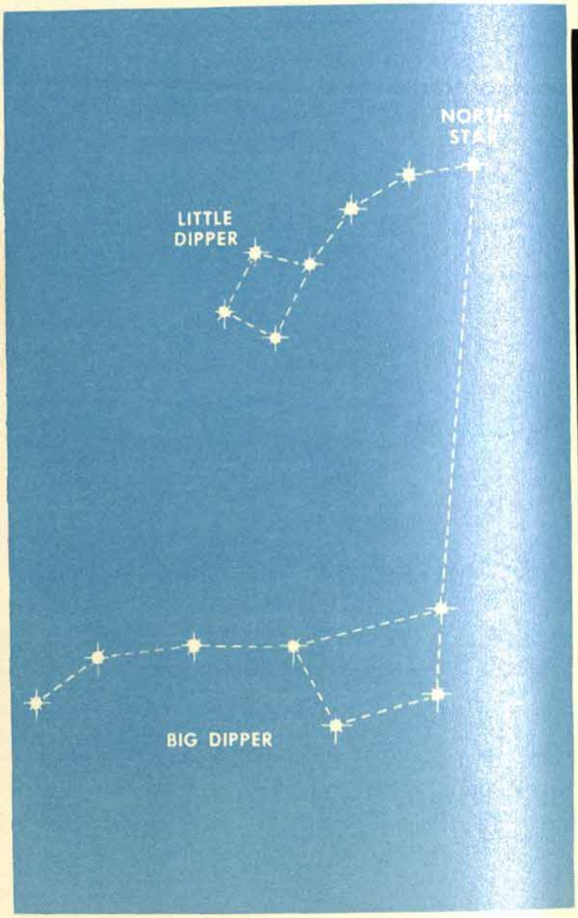
Now let us consider the stars. Even on this scale, with the little pea representing the earth, the pinhead the moon, and the big pumpkin a block away the sun, we must imagine another pumpkin over 16,000 miles away in order to show the proper proportion of distance to the nearest star. Remember, this is to the *nearest* star. Most stars are much farther away, so far that we can hardly imagine the distance. On a clear, dark night we can see about 2,000 stars but there are millions of them that can be seen only through a powerful telescope. No doubt there are many millions beyond those that no one ever has been able to see.

In the last part of the sixteenth century, the great Italian scientist, Galileo, constructed a crude telescope by which he made many startling discoveries. With this instrument he saw that the moon was not a smooth object like a plate, as men before him had thought, but was ball-like and very rough. He saw spots on the sun which, as we know now, are caused by the explosion of gases. He pointed his telescope at the planets and learned that Venus goes through phases similar to the phases of our moon. He discovered that the 4 moons of Jupiter, which he could see, traveled around that planet. This had never before been known. From his early observations astronomers have gone ahead to study the stars.



MT. WILSON OBSERVATORY showing huge dome which covers the telescope as shown in lower photo

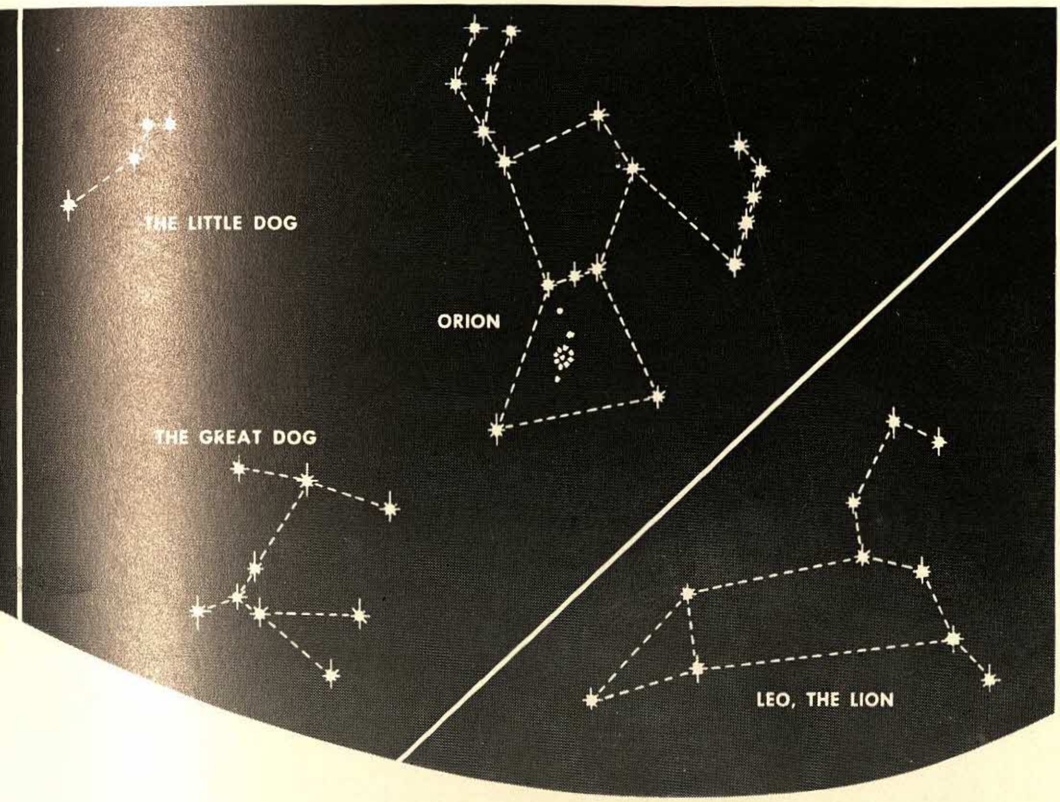




The stars rise and set just as the sun and moon do because of the turning of the earth. In their rising and setting the stars always appear to have the same position in relation to one another. For this reason the stars often are called "fixed stars" to distinguish them from the planets. Scientists tell us that the stars do move in relation to each other, but they are so far away that their changing positions cannot be seen by our unaided eyes and would not be if we could watch the sky for several centuries. But with measurements made by the most accurate instruments, we find that the fixed stars do change their positions gradually.

There is one star, though, that we always see in the same position regardless of the turning of the earth because it happens to be directly in line with the North Pole and the axis of the earth. That is Polaris, commonly called the North Star.

It is easy to find because it is the brightest star in that part of the sky. But you can always locate the North Star from the Big Dipper which can be found somewhere in the north on any clear night. Two stars of the Big Dipper outline the portion of the bowl opposite the



handle. They always point toward the North Star although the entire Big Dipper turns in a great circle in the northern sky once every 24 hours. There is also a Little Dipper. The North Star is the end star of its handle.

There are many other stars that appear together in groups. Since man first gazed upward, he found that certain groups made pictures. We call these groups constellations. The shepherds of long ago made up stories about the constellations as they watched their flocks at night. Orion and his Dogs, Leo the Lion, and Pegasus the Winged Horse are a few of the more common ones.

Many stories have been told, too, about the Milky Way. Some people thought that it was the road that led to Heaven. On a clear and moonless night the Milky Way shows very plainly. This long, ragged belt of faint white across the sky really is made up of millions of stars so far away that they look like a milky path.

"FALLING STARS"

WHAT some people call "falling stars" or "shooting stars" are not stars at all. They are meteors—chunks of metal and rock that whirl about in space between the heavenly bodies somewhat like a handful of confetti thrown in front of an electric fan. Often one of these objects comes toward our planet. It may be a mere speck of dust, or the size of a pebble, or weigh several tons. As it nears the earth, the meteor rushes through the air which causes it to glow and appear to be a falling star.

A meteor falls rapidly, at the rate of from 10 to 50 miles a second, and is usually burned out in a second or two. Once in a while a meteor is so large it does not burn itself out by the time it reaches the earth. Then it hits the ground with such force that it makes a hole. That part of a meteor which falls to the ground is called a meteorite. In the desert in Arizona, there is a hole nearly a mile wide that was made by a huge meteorite.

The best time to see meteors is after midnight and in the fall of the year, but on almost any dark night one can be seen occasionally.

The FALLING STAR

I saw a star slide down the sky,
Blinding the north as it went by,
Too burning and too quick to hold,
Too lovely to be bought and sold,
Good only to make wishes on
And then forever to be gone.

—Sara Teasdale

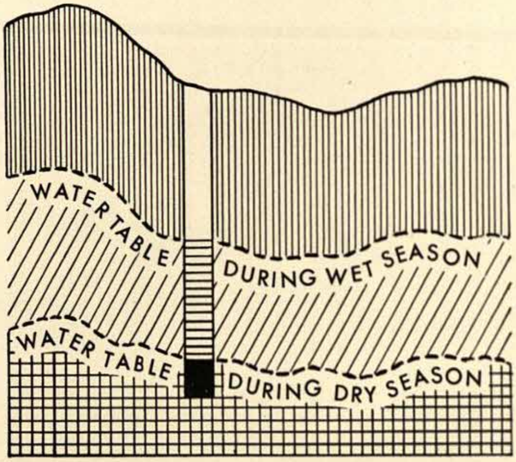
THE EARTH'S SURFACE

THE BIRTH AND LIFE OF A RIVER

WHEN rain falls on the ground, it may soak in or it may run off. If it runs off, it will run toward lower ground, forming a little stream and meeting other little streams on the way. If much rain falls, the stream grows larger and deeper as it reaches still lower ground and other streams join with it. When the rain stops, the little streams dry up. But the ditch they have made remains and carries the water away at the next rainfall. With each rainfall the water washes more and more dirt away and the ditches become bigger and deeper. In time these streams even may cut their way through hard rock.

Smaller streams unite to form creeks; creeks run into small rivers, and small rivers run into larger rivers. This means that more and more water is carried by a single stream which usually flows toward the ocean. The Mississippi River is a good example of the way many streams unite to form a very large river.

But, you might ask, does all the water that helps to form rivers come from rain? Most of it does, but some of it falls as snow. In the North or on high elevations the snow often stays on for months at a time. But when the snow melts, the water trickles down to lower levels and flows into streams.

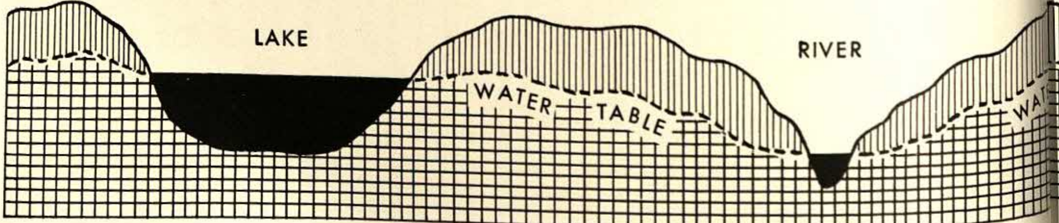


Part of the water soaks into the ground instead of running off and forms two zones of *ground water*. The upper zone usually has only a small amount of water in the spaces in the soil. The lower zone has all the spaces filled with water. The top of the lower zone is called the *water table*. When heavy rains occur the water table rises nearer to the surface. When there are severe droughts the water table sinks deeper into the ground. Wells must be dug deep enough to reach below the water table at all times to insure a steady supply of water.

You may wonder what ground water has to do with rivers. In one way or another much of the ground water also runs into streams. On hillsides it sometimes seeps out forming springs. This spring water may run away to help make a river or it may collect in a low basin of land and form a lake. When lakes overflow, the water runs out to form rivers.

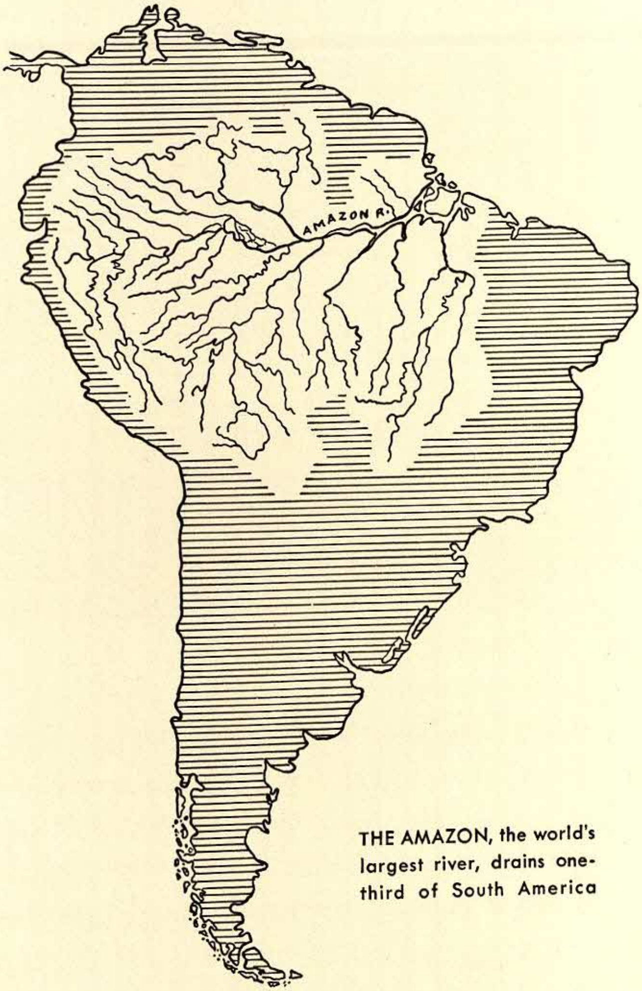
If streams have cut into the ground below the water table, there is usually a constant flow except during the worst droughts. By cutting below the water table, rivers become permanent streams. So we see that after all, ground water does have something to do with rivers.

There are a few rivers that have been formed in a different way. Our earth is very, very old and during the past, some of the land near the ocean has sunk or the ocean floor has risen. Water backed into valleys, making rivers. These are called drowned valleys. They also may receive water from springs or streams just as other rivers do. There are many along the eastern seacoast, especially in New England.



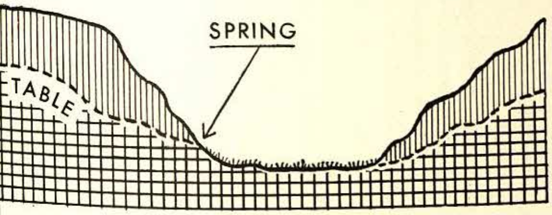
The Hudson River is an example. San Francisco Bay and Puget Sound on the west coast though not rivers, were also formed in this way.

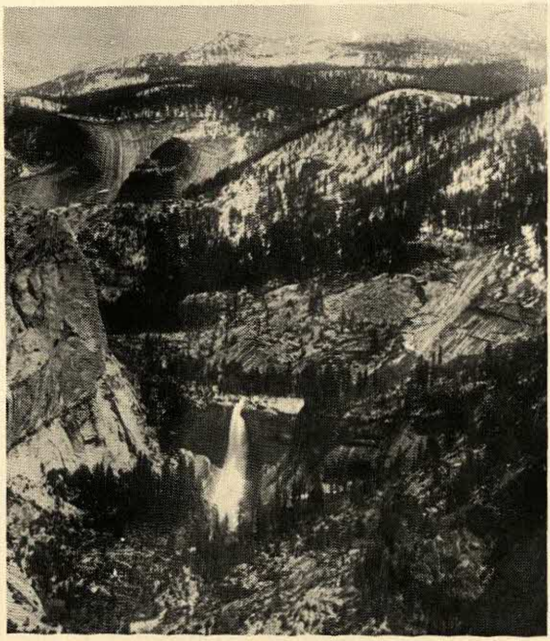
Rivers are *youthful, mature,* or *old.* When a river system has eaten its way into the soil to form valleys, the gullies and the valleys are usually quite steep-sided and V-shaped. Such a river is in the state of youth. Youthful streams usually have very crooked courses—they bend here and there to fit themselves to the low places in the land. There are deep canyons, rugged cliffs, and steep ridges in a region that has many youthful streams.



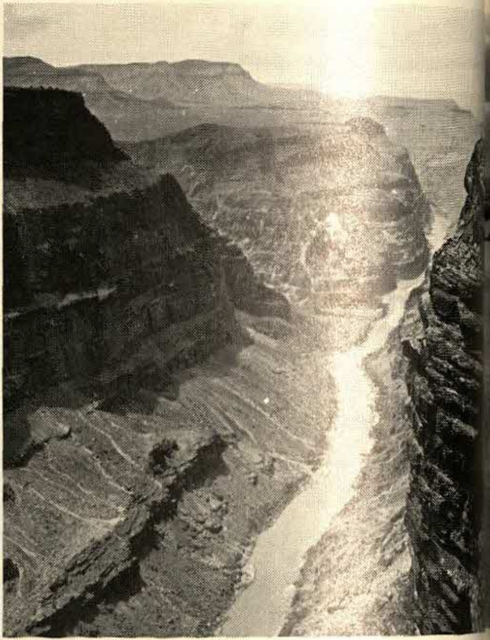
THE AMAZON, the world's largest river, drains one-third of South America

But running water wears away soil and rock and after millions of years a youthful river valley may become a mature river valley. The tributaries branch and rebranch. They cut through the ridges and high crests of land. Finally when the water has washed the land from the high ridges into low places the land becomes more rolling and gently sloping. The stream valley is then called mature, or middle-aged. Such a valley is broad and its sides are not steep and rugged. The curves of mature rivers are less sharp and the water does not flow so rapidly.





Young river valley



Mature river valley

As the hills and crests continue to wear down, the countryside becomes more and more level. The water runs off more slowly and the land wears away less. Soil that washes from the hills is deposited in lowlands. The water of the river may cut into the banks and widen the stream bed so that, as the years pass, the river wanders back and forth across a nearly level plain. Such a river is called an old river. In an old river valley the land is not much higher than the river banks.

Sometimes heavy rains or melting snow empties into a river so rapidly that the banks cannot hold it all. Water rushes over the land, making a flood. In some regions floods often come in the spring and do serious damage. We now are learning to put dams in some of the smaller streams to help hold part of the water back from the big rivers, such as the Ohio and Mississippi, that sometimes flood. Also grass and trees planted on hillsides keep the water from running away so swiftly. They not only help to prevent floods, but prevent the soil from being washed away.

A river means different things to different people. To many a boy in a small town, it means the old swimming hole or a bank to sit on

Old river valley

with a fishing pole and a can of worms. To some men it brings memories of wading in a trout stream that winds through a beautiful forest. Other people think of boat rides or ice skating or waterfalls.

A farmer in southern Idaho might think of a river in terms of the water it supplies to the ditches that irrigate his land; some Chinese families on the Yangtze River would think of the water that floats the houseboats on which they may spend most of their lives. To people of hundreds of our cities and towns a river means the source of their water supply and perhaps of their electric power. Rivers have always been very important to many people all over the world. The Nile in Egypt and the Ganges in India have been such a blessing to the people along their shores that even today many of the natives regard them as sacred.

Rivers were the principal highways of most of the American Indians. The routes of the explorers and the locations of the early settlements were determined by the courses of the rivers. Even after the railroads were built, some of these inland waterways have continued to be our cheapest means of transportation.

Most great cities have grown up along the banks of rivers. Even great ports for ocean shipping, such as New York and London, are located on rivers because of the excellent harbors that the rivers provide. Detroit is an example of a city that is located on an important inland waterway.

Many cities are located at a particular place on a river for a different reason. For example, some of the early settlers sailed their ships up rivers of the Atlantic coast until they were stopped by rapids and falls.

There villages were started which, taking advantage of the water power, developed into cities. Trenton on the Delaware, Richmond on the James, and Augusta on the Savannah are representative cities of this type. They are called "fall line cities" and mark the line where the streams leave the hard rocks of the Piedmont area to flow over the softer bed of the Coastal Plain.

In many cases rivers act as natural boundary lines between states or between countries. Few people ever stop to realize how very important rivers have been in shaping the lives of people, of cities, and of nations.

You will no doubt be interested in a comparison of some of the leading rivers. The Amazon, while not the longest river, is the world's largest. It drains one-third of South America, a region nearly as large as the United States. Even today, except for the airplane, the Amazon is practically the only means of transportation in that whole area.

PROMINENT RIVERS OF THE WORLD

Name	Flows into	Length in miles
Mississippi-Missouri	Gulf of Mexico	4,240
Amazon	Atlantic Ocean	4,000
Nile	Mediterranean Sea	4,000
Yangtze	Yellow Sea	3,000
LaPlata	Atlantic Ocean	2,300
Volga	Caspian Sea	2,300
Yukon	Bering Sea	2,300
St. Lawrence	Gulf of St. Lawrence	2,100
Danube	Black Sea	1,725
Euphrates	Persian Gulf	1,700
Colorado	Gulf of California	1,650
Rio Grande	Gulf of Mexico	1,650
Ganges	Bay of Bengal	1,500
Columbia	Pacific Ocean	1,270

GLACIER—ALASKA

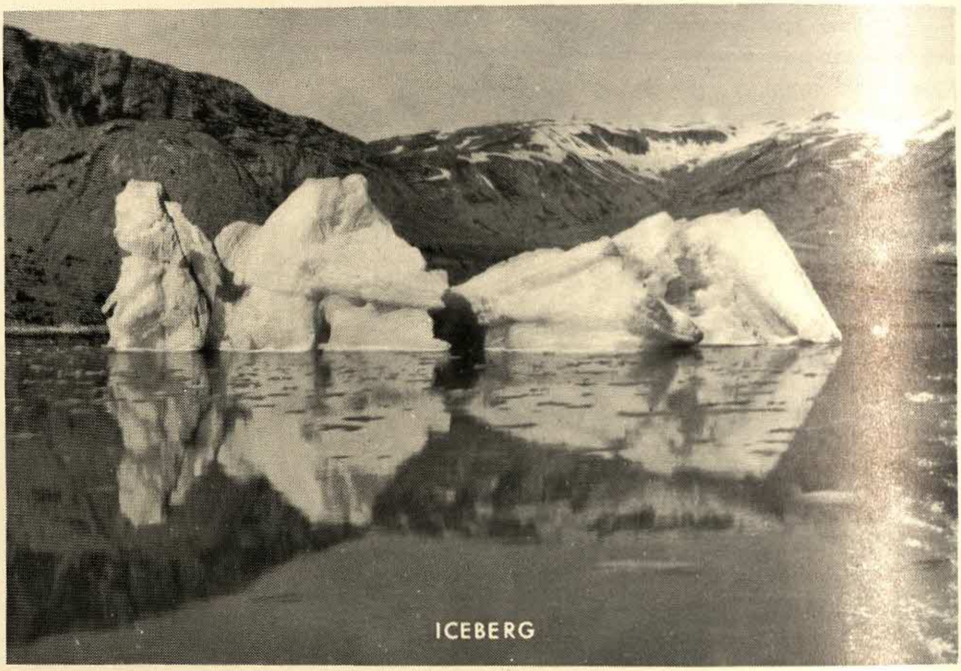
MOVING FIELDS OF ICE

CHILDREN who like to play in the snow often exclaim, "Oh, I wish the snow would last forever!"

Have you ever wondered what would happen if the snow did not melt? In the cold Arctic regions and on some of our very high mountains, much of the snow does last right through the summer. By watching what takes place in these regions we have a chance to find the answer to our question.

The snow that falls there does not stay fluffy like newly fallen snow. It may melt a little on top, but then as colder weather comes, it freezes almost like ice. Each new snowfall piles up more and more snow. Year after year for thousands of years this may repeat itself. And the ice-from-snow layer gets thicker and thicker.

As this ice-snow piles up very high, its own weight causes the ice at the bottom to become plastic and move outward at the edges toward lower ground. It is these slowly moving ice sheets on land that we call glaciers.



ICEBERG

Glaciers that form on high mountains move slowly down the valleys toward the foot of the mountains. They may move only a few inches or a few feet a day. When their forward edges get down where the weather is warmer, they melt more rapidly.

There are a number of small glaciers in our western states. The most important of these are on volcanic peaks—Mount Ranier and Mount Baker in Washington, Mount Hood in Oregon, and Mount Shasta in California.

Most of the island of Greenland is covered by a huge glacier that has been collecting for hundreds of years. The ice in places is more than 8,000 feet thick. It is higher toward the center, so the ice creeps slowly toward the sea. Huge tongues of this ice push their way into the ocean. They break off in the water and float away from the land in the form of icebergs. Seamen in the North Atlantic must keep a sharp lookout for them as a collision with an iceberg will sink, or at least seriously damage, a ship.

Thousands of years ago large glaciers, much like the ice sheet now on Greenland, moved southward across Canada and much of the United States. Such large glaciers have more than once moved southward and then melted back. At least four of these advances and retreats are known to have occurred.

As these huge ice masses with their tremendous weight moved slowly forward, loose soil and rocks were frozen into the bottom of the ice and carried along. The glaciers, thus shod with hard rocks, acted like a huge rasp or file in wearing away the solid surface rocks over which they were moving. Softer rocks were ground to flour-like particles. Valleys were deepened and broadened. Hills and mountains were carved down, and more and more material was added to the rock load carried by the moving glacier. As the ice melted, this enormous amount of debris, composed of rocks of all shapes and sizes, was left to form irregular hills and obstructions that blocked the flow of water and formed many large basins. These hollows and basins form most of our northern lakes. Many waterfalls, even Niagara, were first formed by great quantities of water from the melting glaciers flowing over the uneven surface of the land.

Even today in the mountains of northwestern Montana, there remain between 80 and 90 glaciers. A section of the state has been set aside as Glacier National Park. There are many glaciers today in the mountains of Alaska and Norway. In fact, all of northern Europe was at one time covered by a huge ice sheet. The little country of Switzerland still has about 1,000, and the fjords of Norway were formed, or at least deepened, by glaciers.

So we see that enough of the fluffy snowflakes packed together into solid sheets of ice form glaciers, and glaciers have made great changes in the surface of the earth.

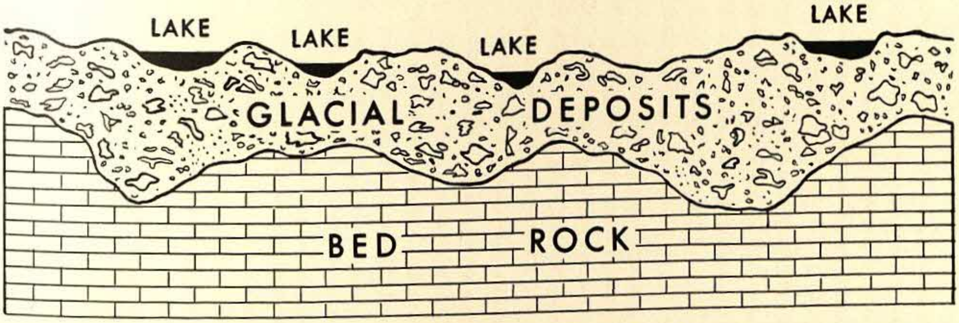


Diagram showing small lake basins formed by irregular distribution of glacial deposits on bed rock surface

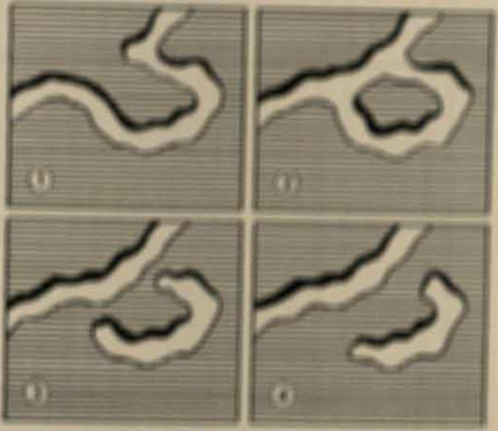
LAKES, LARGE AND SMALL

ON A WARM summer evening what is more fun than to dive into a crystal clear lake and slice one's way through the cool water! Or perhaps to you a lake suggests a pleasant day of fishing or sailing.

Lakes surely rank along with rivers in their importance to mankind. They are centers of recreation. They provide a source of water supply for numerous towns and cities, for irrigation of land, and even much of the water for many of the rivers themselves. They, too, furnish an important means of inland transportation. They hold back water and reduce floods. For example, there are never any floods on the St. Lawrence River because the Great Lakes act as storage basins which release the water quite evenly throughout the year. Lakes are also the source of a large amount of fresh-water fish.

Lakes are found in nearly all parts of the world. The first requirement in the formation of a lake is that there must be a cup or basin in the earth's surface to catch and hold the water. There are several ways in which these basins are formed.

Most of the lakes in Minnesota, Wisconsin, Michigan, and New York were formed by glaciers. The best known lakes of glacial origin are the Great Lakes—Lakes Superior, Michigan, Huron, Erie, and Ontario. Lake Superior is the world's largest fresh-water lake.

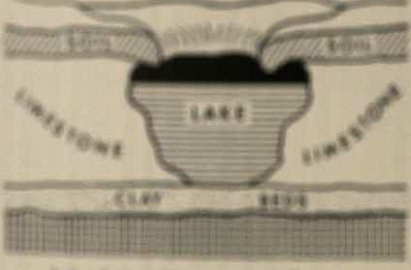


formation of an OXBOW lake

Let us now look at some of the other ways that lakes were formed. There is one in the state of Oregon that is of special interest. Lying as it does in the crater of an old volcano it is rightly called Crater Lake. It is the largest crater lake in the world, being more than 5 miles across, and is known to be about 2,000 feet deep. No rivers flow into it. It is fed entirely by rain and snow that fall directly into the basin.

While we are thinking about Oregon, we may as well look at another kind of lake formation. The Warner Lakes of Oregon were formed by the breaking and slipping of a portion of the earth's crust, the same sort of thing that causes earthquakes. The ground sank enough in places to make basins which filled with water. Several lakes in Tennessee formed after an earthquake shook the lower Mississippi Valley in 1811. There are other lake basins of this type in the United States, in Hungary, in southern Sweden, and in Africa.

Sometimes a river cuts across one of its curves leaving the curve behind. The old curved portion with water standing in it may be walled off from the new stream to form a lake. We call a lake formed in this way, an oxbow lake.



lake formed by water collecting in a SINK in limestone rock

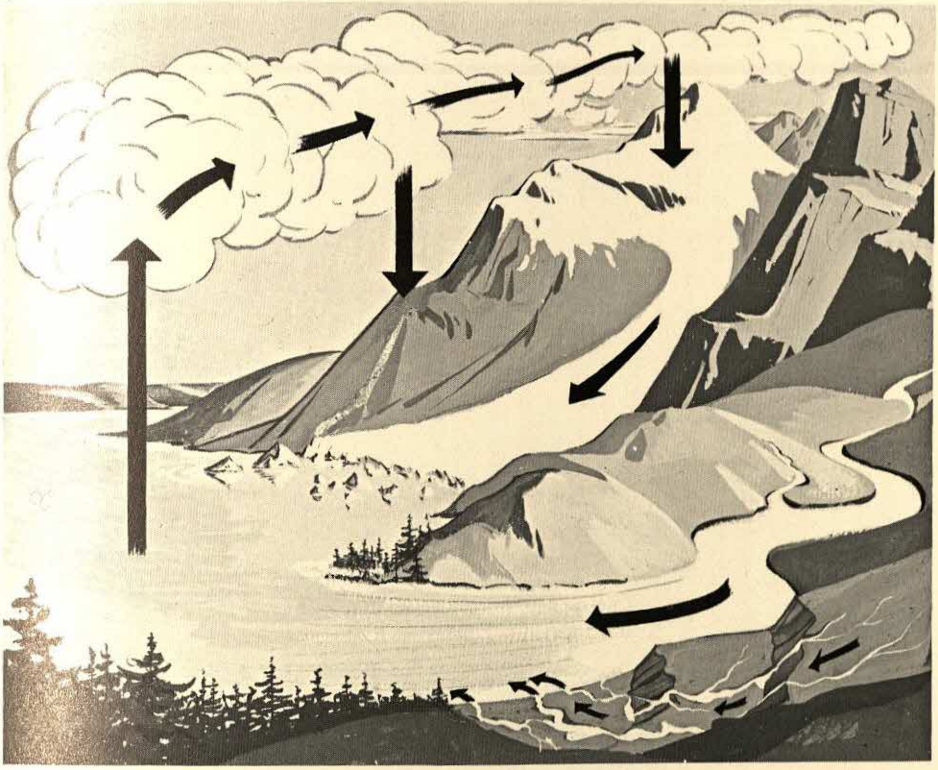
In Kentucky there are hundreds of small lakes that were made by water collecting in sinks in the limestone rock of this region. Sinks are holes formed when running water dissolves the limestone so that the surface "sinks" at that point. Usually sinks that contain water are those whose bottoms are below the water table so they are fed by ground water. Small lakes like this occur, too, in Indiana, central Florida, and many other places. Sometimes lakes are formed by landslides, by beaver dams, by lava flows, and by other obstructions that stop the flow of water.

Almost all lakes have one or more streams running into them and an outlet through a stream or river. But there are a few lakes which have no outlets. In that case, the minerals which are carried into the lake over thousands of years remain there because the only loss of water is through evaporation, and the water becomes more and more salty. The best example of this in the United States is Great Salt Lake in Utah.

Since the water in lakes is not moving rapidly, the water usually does not hold large quantities of dirt in it. Many lakes are clear and blue. Eventually, though, they become filled with dirt because rivers and streams carry it in. So probably our present lakes will gradually disappear. Thus, it has been said that rivers are enemies of lakes. But we need not worry about the gradual disappearance of the lakes because it takes a long, long time for lakes to fill. Anyway, new lakes are likely to form wherever nature's many forces make new basins on the earth's surface.

PROMINENT LAKES OF THE WORLD

Name	Location	Area in Sq. miles	Greatest Depth in feet
Superior	U.S.A.-Canada	31,810	1,180
Victoria	East Central Africa	26,200	270
Aral	U.S.S.R.	24,400	222
Huron	U.S.A.-Canada	23,010	750
Michigan	U.S.A.	22,400	870
Tanganyika	East Central Africa	12,700	4,700
Great Bear	Canada	11,200	270
Nyassa	South Africa	11,000	2,580
Erie	U.S.A.-Canada	9,940	210
Ontario	U.S.A.-Canada	7,540	738
Great Salt Lake	Utah	1,500	25



The water cycle is the process by which water travels from sea to air to land to sea again, in an endless pattern, as shown above.

SOME WONDERS OF THE SEA

AT LEAST three-fourths of the surface of the earth is covered by water. We call the large bodies of water between the continents oceans or seas. The main difference between an ocean and a sea is largely a matter of size and depth. The water in both is salt water. But most people choose to call the largest bodies of salt water, oceans, and the smaller ones, seas. So looking at a globe or a map of the world we find the words, Pacific Ocean, Atlantic Ocean, Indian Ocean, Arctic Ocean. We find, also, Caspian Sea, Bering Sea, Black Sea, and North Sea.

Water tends to flow to the lowest place it can find. As the ocean is lower than the land, when rain and snow and hail fall on the land, some of the water runs off to the ocean through the streams. From the ocean the water evaporates to form clouds again. We call this endless process the *water cycle*.

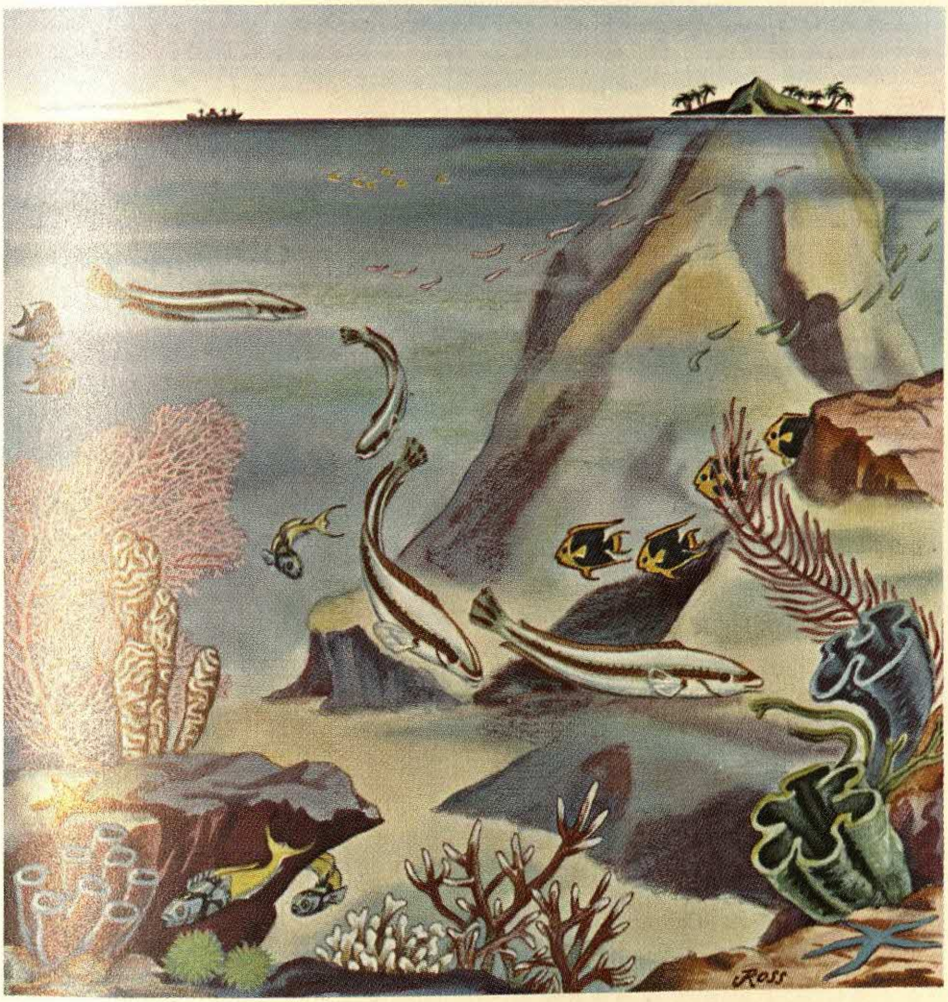
The water that runs into the ocean carries salt and other minerals with it. When the water evaporates, it leaves the salt behind. In this way the ocean continues to get more and more salty. Since ocean water is too salty to drink, ocean-going ships have to carry a supply of fresh water. If all the salt from the ocean were separated from the water and spread out in a layer, it would make a blanket 150 feet deep covering the entire surface of the earth!

The bottom of the ocean is not even and level, although more so than most of the land. If all the water could be drained away, we would see that the ocean floor not only had deep valleys but also great ridges of land rising from it. In some places mountains come up above the top of the water to form islands. The average depth of the ocean is a little over 2 miles, but some places are over 6 miles deep. The deepest point that has been located is near the Marianas Islands, where a depth of nearly 7 miles was measured. This is much deeper than the highest mountain is tall.

Many forces are gradually wearing down the land and carrying it into the ocean. Rivers, as they slow down upon entering the ocean, deposit the soil and other sediment they carry, sometimes making deltas, as such formations of land at the mouth of a river are called. Ocean waves lashing and beating against the shore line wear down the coast, even the rocks in time. Tides and ocean currents are continually scouring the bays and shores. Sometimes there are slight risings or sinkings in the ocean floor itself. Due to all of these things, the shore line of the ocean is gradually changing.

A DELTA

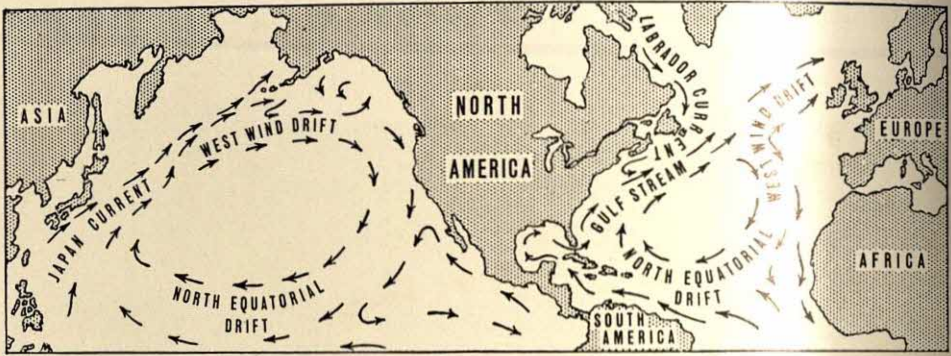
Ocean currents are caused by winds and the unequal heating of the water. The two principal currents are the Gulf Stream and the Japan Current. The Gulf Stream, flowing from the Gulf of Mexico north along the east coast of Florida, is joined by another branch from the Caribbean Sea. This body of water several miles wide is like a river within the ocean. It moves at the rate of 3 to 5 miles an



ISLANDS are mountain tops which have risen above the ocean's surface

hour, carrying warm water north and east across the Atlantic to give the British Isles and the coast of Norway a mild climate in spite of their being so far north. The Japan Current does the same for our own northwest coast and for that of British Columbia and southwestern Alaska.

There is an abundance of life in the ocean. There are ever so many kinds of curious underwater creatures as well as many fish of various types, colors, and sizes. There are whales that weigh over 100 tons. There are immense plants that sway in the almost constantly moving water. There are other animals and plants so small that they can



Important ocean currents

be seen only under a microscope.

The ocean is a fascinating and amazing jungle of strange plants and animals. But because of the tremendous pressure of the water at its lower depths, we cannot explore its deeper parts without special equipment.

A French scientist invented a strong steel vessel that will not break under extreme pressure. It is called a bathyscaphe. In it men have explored the ocean at a depth greater than six miles. By making these trips to the bottom of the ocean we are learning more about our mysterious underwater world.

OCEANS AND SEAS

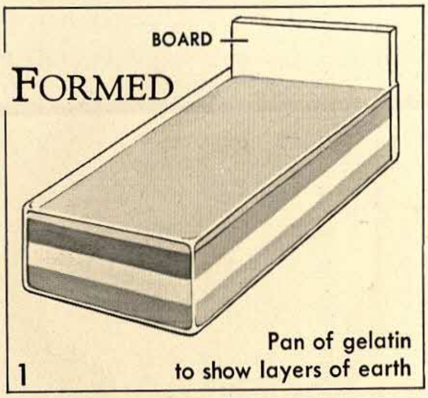
Name	Area in Square miles	Greatest Depth in feet	Location of Greatest Depth
Pacific Ocean	63,750,000	35,800	Off Mindanoa P.I.
Atlantic Ocean	31,830,000	27,965	Off Puerto Rico
Indian Ocean	28,357,000	24,440	Off Sumatra-Java
Antarctic Ocean	7,500,000	. . . . . .	. . . .
Arctic Ocean	5,440,000	18,546	77°45′N., 175°W
Malay Sea	3,140,000	21,340	Banda Basin
Mediterranean Sea	1,145,000	14,435	Off Cape Matapan
Caribbean Sea	750,000	20,568	Off Cayman Islands
Japan Sea	389,000	4,428	Central Basin
Red Sea	169,000	7,254	Off Port Sudan
Baltic Sea	163,000	1,380	Off Gottland

HOW MOUNTAINS ARE FORMED

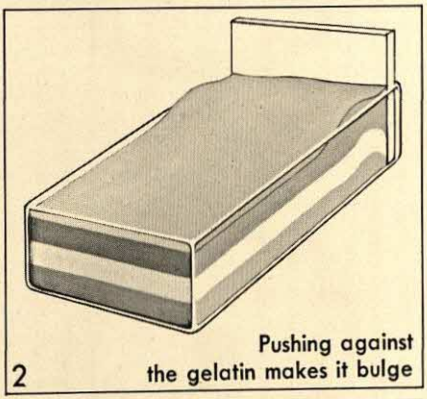
YOU can see how mountains are made by a simple experiment. First, get three packages of gelatin of different colors such as red, green, and yellow. Then dissolve one of them in a cup of hot water and pour it into a small pan about 4 inches deep and 4 or 5 inches wide. After the gelatin has cooled and set, dissolve another package and pour it on top of the first. After this has set, put the third on top of the second and let it set. Now you have three colored layers of gelatin in the pan. Imagine these are layers of rock in the earth's surface.

Let us now proceed with the experiment. Find a thin board just the width of the pan. Carefully push the board downward between the gelatin and one end of the pan. Then push the board firmly and slowly against the gelatin. The gelatin begins to bulge in some spots. Continue to push and watch very carefully. The layers are now pushed into curves. You have made mountains. Most of the real mountains have been made in much the same way.

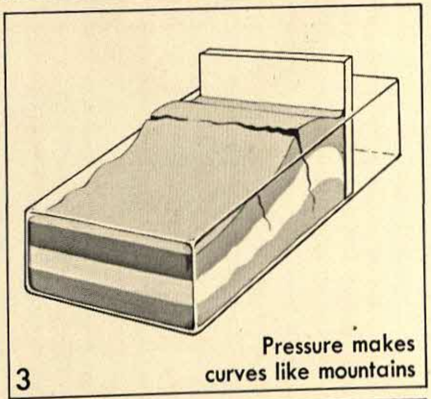
Perhaps the gelatin breaks and



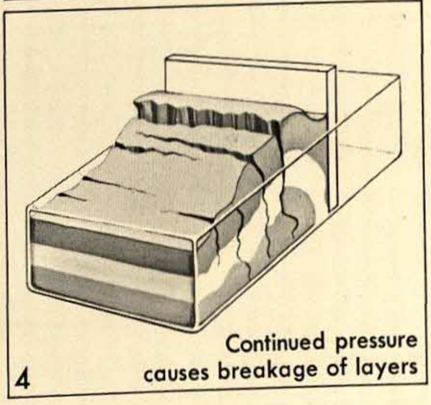
1 Pan of gelatin to show layers of earth



2 Pushing against the gelatin makes it bulge



3 Pressure makes curves like mountains



4 Continued pressure causes breakage of layers

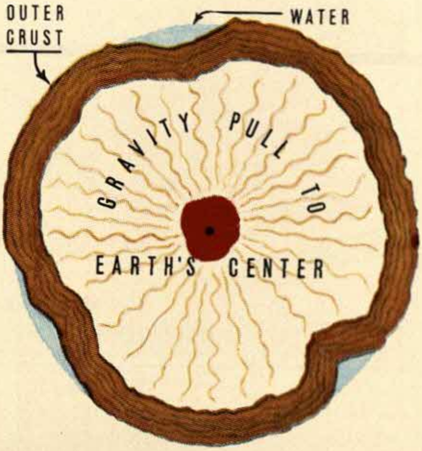


Diagram of earth, cut in half, to show probable original shape

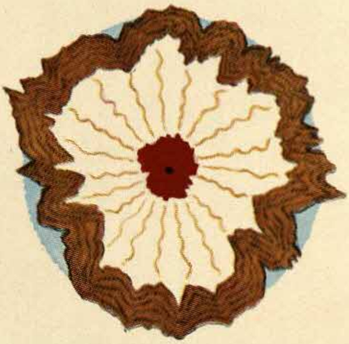


Diagram showing effect of pull of GRAVITY on earth's crust

one layer pushes over another as you move the board. If that happens do not think your experiment is a failure. Sometimes the same thing happens to the layers of rock during the process of mountain building. Whatever happens your experiment is a success! The rough tops and broken pieces standing on end or overlapping one another still may represent mountains.

If some great force pushed the rocks of the earth the way you pushed the gelatin, the rocks would rise far into the air at each bulging curve. The higher bulges would be the highest ranges of mountains. The lower bulges would be lower ranges of mountains.

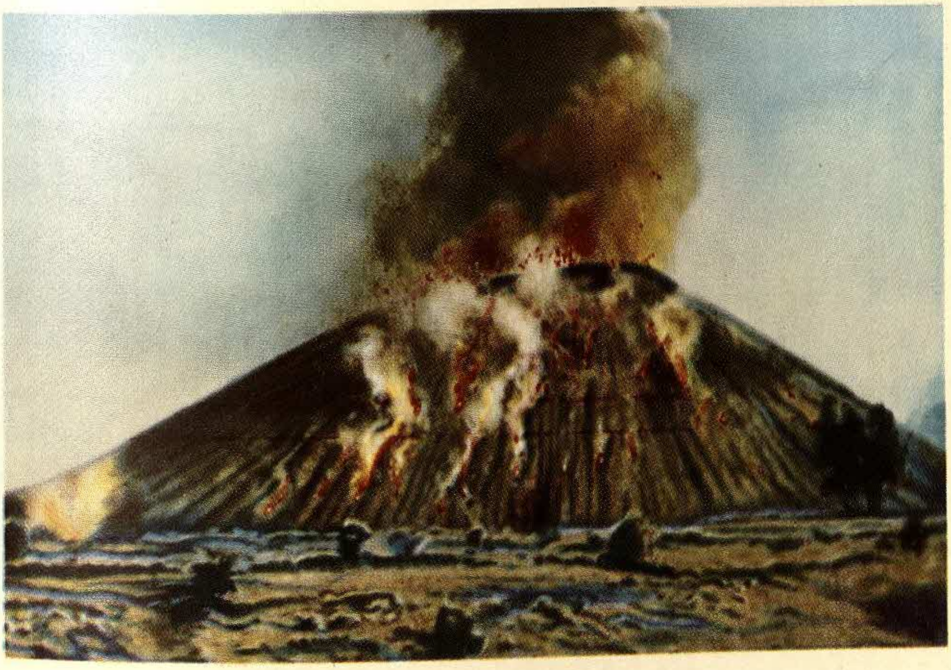
You may wonder what great force would be pushing sideways on the rocks of the earth's crust. The answer to this question is not easy. In fact, all the people who have studied mountain building carefully do not agree on what caused the force. But they do agree that the earth's crust was buckled up by forces.

You have learned before that gravity pulls everything on the earth toward the earth's center. Gravity also pulls the earth's crust toward the center. This continual pull on the earth's crust tends to make the total size of the earth smaller. But the land with its layers of rock cannot possibly be pulled centerward very far without something breaking or bulging.

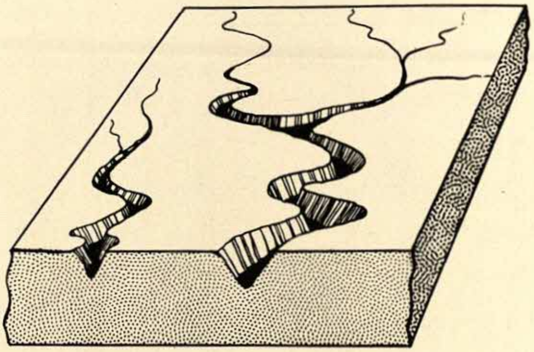
There just is not room for all of this outer crust to stay smooth and level when the earth is compressed into a smaller ball. The outer part is too large to fit when it is pulled inward, so it cracks and buckles and pieces push sideways; some pieces get tilted up and even overlap one another. Just as you would expect, the heavier parts of the earth's crust are pulled inward the most and the lighter parts are left standing higher. And as the pulling inward continues, the higher parts get pushed still higher.

Mountains that are formed in this way usually occur along the coasts or in lines running about the same direction as the coast lines. The Appalachians near the eastern coast of the United States were probably formed in this way. Another example is the Sierra Nevada in California. Generally mountains do not stand alone. They are usually parts of a long ridge of mountains called a range.

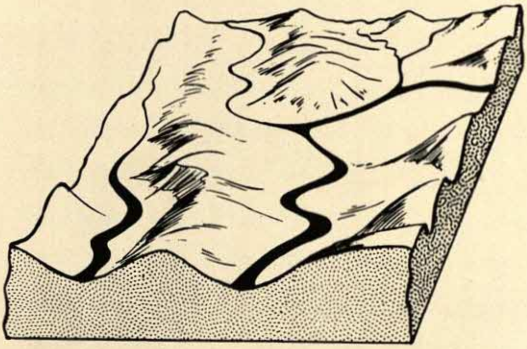
Mountains are formed in other ways too. While some of the land is raised into folds as we have just described, other areas are raised into high flat lands called plateaus. Water forms streams that run across the plateaus. The streams gradually cut down the rock. Finally as many huge gorges are made, the plateau becomes rough and ragged. The high points then look like mountains. The Catskill Mountains in New York were formed in this way. Pikes Peak in Colorado was formed by the slow process of streams wearing away a plateau, leaving the harder rock standing out by itself.



PARÍCUTIN — the famous Mexican volcano



Erosion starting into mountain plateau



Same plateau in late stage of erosion

There is still a different kind of mountain. In many places over the earth, hot liquid rock called lava has oozed out of holes in the ground. Such an opening is called a volcano. This lava, along with cinders and ashes blown out by hot gases from within, collected into heaps around the holes and formed cone-shaped hills. As more and more of this hot material was thrown out, the hills became higher and higher until finally they were mountains. The lava gradually cooled and formed hard rock.

Some of the world's highest mountains are volcanic mountains. Mount Aconcagua in Argentina is one. Mount Rainier in Washington is another. The Hawaiian Islands in the Pacific Ocean are really the tops of volcanic mountains. They would be very high if their bases were not so deep in the water.

All of the processes that have formed mountains in the past are still at work today. But mountains are not often made overnight or in a year. For most of them it has taken millions of years.

There was a case in Mexico, though, a few years ago, where a volcano was formed suddenly. Near Paricutin a farmer and his son were plowing in a field when all at once steam and hot ashes began coming out of the ground near by. Within a few hours hot lava and ashes belched forth which flowed over the countryside and destroyed plants and trees, and in time even buried a number of villages. For some time before the eruption, the ground where the volcano started had been warmer than at any other place in the area. In the cool evenings picnickers had often gone there to enjoy its warmth. Many of these people must have wondered what made the ground so warm. Imagine their surprise when the earth opened with a rumbling sound and a smoking volcano started to grow.

The United States claims one volcano that has erupted at times in recent years. It is Mount Lassen in the northern part of California. The surrounding region containing hot springs and bubbling mud-holes, which tell of the intense underground heat, has been set aside as a national park.

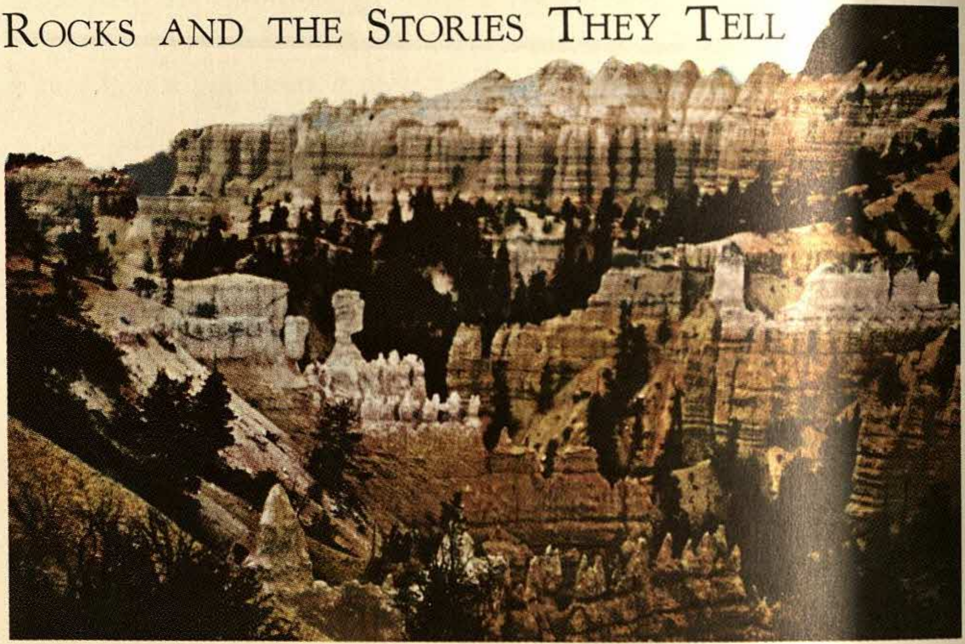
Mountains have greatly influenced the lives of people. Certain high ranges cause plenty of rainfall on one side of the mountains and allow the other side little or none. Mountains often serve as boundary lines between states and nations. They yield important minerals and precious jewels. They are the source of many streams. They provide scenery and recreation for millions of people.

PROMINENT MOUNTAINS OF THE WORLD

Name	Location	Height in feet
Mt. Everest	India	29,610
Mt. Aconcagua*	Argentina	23,080
Mt. McKinley	Alaska	20,300
Mt. Kilimanjaro*	East Africa	19,319
Mt. Orizaba*	Mexico	18,209
Mt. Popocatepetl*	Mexico	17,888
Mt. Matterhorn	Switzerland	14,780
Mt. Whitney	California	14,501
Mt. Rainier*	Washington	14,408
Long's Peak	Colorado	14,255
Mt. Shasta*	California	14,161
Pike's Peak	Colorado	14,110
Mauna Loa*	Hawaii	12,675
Fujiyama*	Japan	12,395
Mt. Hood*	Oregon	11,245

*volcanic peaks

ROCKS AND THE STORIES THEY TELL



BRYCE CANYON — a wonderland made by erosion

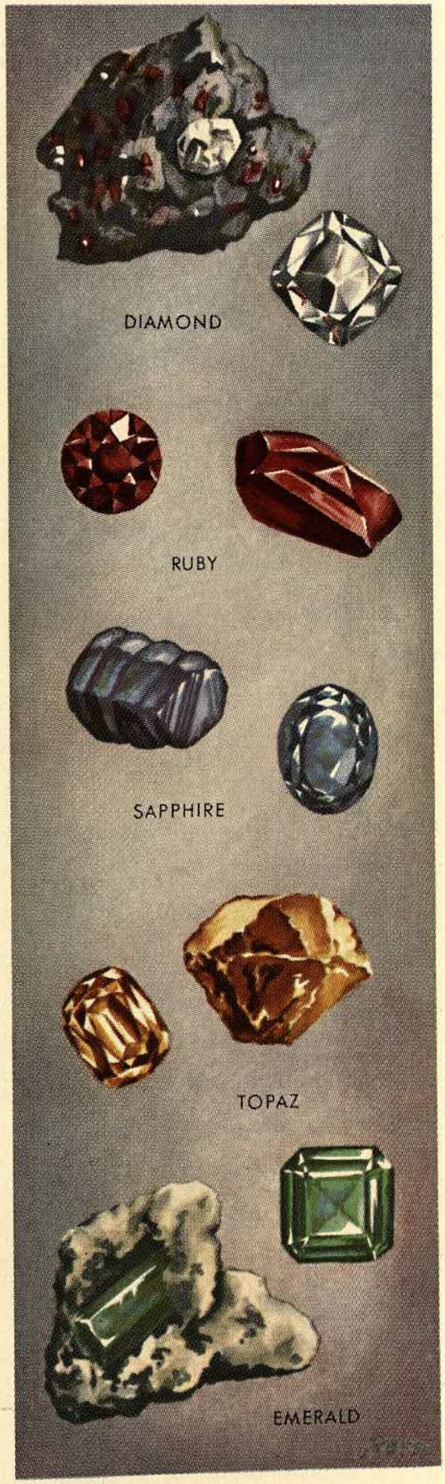
THE SOLID part of our whole earth is composed entirely of rock. Of course, there are bodies of water covering most of the earth's surface and soil covering much of the land. But underneath water or soil, if we dig down deep enough we find hard rock. And even the soil is tiny particles of rock. Our metals and gems are part of the rock mass. Rocks are important to us, also, in another way.

Scientists tell us about mountains and rivers formed millions of years ago; about areas of dry land that were once at the bottom of the ocean; about different periods or stages in the growth of plant and animal life, such as the Age of Coal, the Age of Reptiles, and an Ice Age, when most of Europe and North America were covered by a huge glacier. We are told of these and many more events that occurred before man kept any records, even long before man himself appeared on the earth. It is natural to wonder how anyone can know so much about these things. The answer is that the scientists have learned them from the records kept by the rocks.

We can understand all this better if we examine the history of the rocks themselves. It is believed that the earth at first was a red, hot mass of gas and molten rock. As it gradually cooled down, a solid rock crust was formed. During this long process, the rock was warped, shattered, worn down, mixed, heated, and changed into new forms. It received just about every kind of treatment. New rock was made from the wreckage of older rock.

Rocks are composed of minerals. Some rocks contain only one mineral, others are made of several. Most minerals are compounds containing two or more elements, about which more is told in the story, "What the World Is Made Of," beginning on page 101. Quartz, composed of one part silicon and two parts oxygen, is an example of a very common mineral. Ordinary sand is largely composed of quartz grains.

Few of our metals exist in nature in their pure state. Instead they come from ores, or minerals, that are combinations of metals with other substances. For example, most of our iron comes from an ore called hematite, a combination of iron and oxygen. It is a dark red-colored mineral so that rocks containing it have a reddish color. A wide variety of colors appears in the minerals. It is these colored minerals which give color and beauty to the rocks.



Original and polished forms of several well-known gems

If you were to examine various minerals you would find that some of them are very hard, some quite soft. Surprising as it may seem, graphite, of which the "lead" in your pencil is made, and coal are both composed of the same substance as diamonds. A diamond is the hardest substance known. Graphite is quite soft and greasy, so much so that it is used for making slippery surfaces. There is nothing about the beautiful and precious diamond, which sells for hundreds of dollars a carat, to make one think of coal, which sells for a few dollars a ton, except that they are both made of carbon. The diamond came from bits of carbon which in the earth's processes were crystallized by tremendous and unusual heat and pressure.

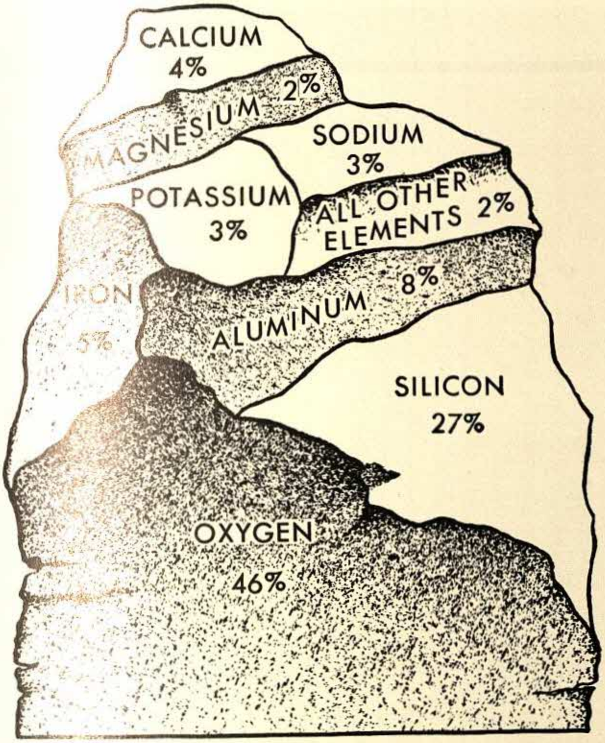
Thus we see that the same minerals may be different because of special treatment that they received. Also rocks containing the same minerals may be different because these minerals are mixed in different proportions. As the result of various mixtures and the way they were treated there are many varieties of rock. We can best understand them if we examine the ways in which rocks were formed. There were three principal ways.

Ages ago when the earth was very hot, much of the matter from which rocks are made was melted into a liquid. When the liquid rock cooled, a special kind of rock was formed. These rocks are called *igneous* rocks, meaning "formed by fire."

When sand and sea shells and other particles settle in a body of water, a layer of rock is gradually formed. At the bottom of the ocean sea shells continually collect and, after thousands of years, deep layers of *sedimentary* rocks are made. As portions of the earth's surface have shifted, many of these sedimentary rocks, which once were at the bottom of the sea, are now on land.

Both igneous and sedimentary rocks are sometimes changed by great pressure or heat into another type. In the pushing and sliding of parts of the earth's surface, which make mountains and valleys and cause earthquakes, some rocks get enormous pressure put on them that may change them considerably. The new type of rock formed in this manner is given a big name that means "changed." The name is *metamorphic* rock.

So we have three types of rock: igneous, sedimentary, and meta-



EARTH'S ABUNDANCE OF MATERIALS IN ROCKS
SHOWN IN APPROXIMATE PERCENTAGES

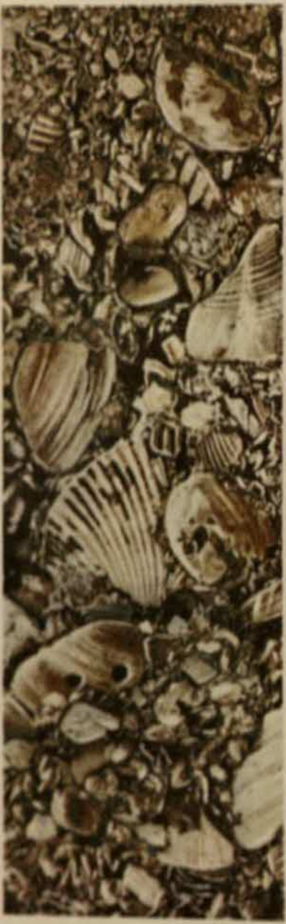
morphic. Granite is one of the most common igneous rocks. It is a very hard rock with a great deal of quartz in it. Lava from volcanoes forms into igneous rock.

A common sedimentary rock is limestone. As it is often formed from sea shells settling to the floor of the ocean and becoming cemented together, most of the limestone is gray in color. It is a fairly soft rock, not difficult to cut, and makes an excellent stone for buildings.

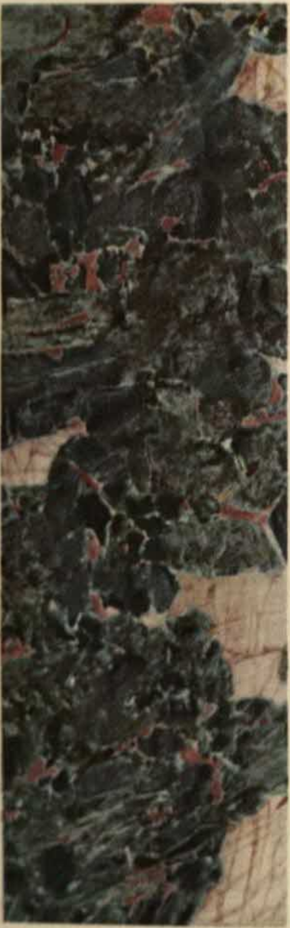
Sandstone is also sedimentary. It is formed by small grains of sand being firmly cemented together. This often happens to sand that settles to the bottom of a stream and remains there over a long period. Another sedimentary rock is shale which is formed by clays and mud settling from water and gradually hardening.

When granite is changed by heat and pressure, the minerals become arranged in streaks or bands and the rock is then called gneiss. When ordinary mud hardens it is called shale. This may be changed by heat and pressure to form slate. Slate is harder than shale and because it breaks into thin sheets it is used for roofing shingles. When limestone is crystallized by heat and pressure, it becomes marble. Gneiss, slate, and marble are examples of metamorphic rocks.

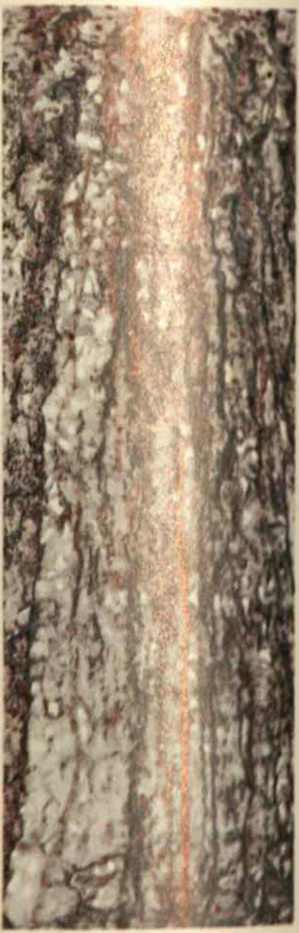
Scientists who study the rocks and from them piece together the history of the earth are called geologists. *Piece together* is what they have to do with the facts they find in order to learn the whole story. For although the layers of rock formed at the different periods con-



SHELL LIMESTONE



GRANITE



GNEISS

tain records of what was happening on the earth at that time, the rocks have been warped and shifted so much that to read them is like reading a book that has been torn and battered and damaged, with some of the pages missing.

It is in the sedimentary rocks that we get most of our information about the earth's history. Sea animals died and their bodies sank to the bottom of the ocean. Rivers and floods washed huge loads of sediment into the ocean and into lakes, carrying with it the bodies or skeletons of land animals that also settled into the mud. As the layers of limestone and shale and sandstone were formed, they held embedded in them these fossils, or remains, of the life of that particular period.

The oldest rocks are largely igneous, and no evidence of life appears in them. The very old sedimentary rocks also show nothing, but the earliest forms of life were doubtless small and soft and easily destroyed. However, as living things developed bones and shells of hard material, they began to leave a permanent record behind them. As layer after layer of rock was built, traces were left of the more advanced forms, fossils of ferns, skeletons of fish, amphibians, reptiles—some of them huge monsters—animals, and plants, similar to those we have today. We can follow the development of life by studying the rocks.

All of those records remain for man to study and to ponder over. As we said before, they often are mixed up but many times nature's processes have helped us by making the pages and the stories they tell easier to find. Upheavals in the earth's crust have placed large areas that were once under water, high and dry. Running water has cut deep canyons, leaving the layers of rock exposed.

FOSSIL embedded in limestone

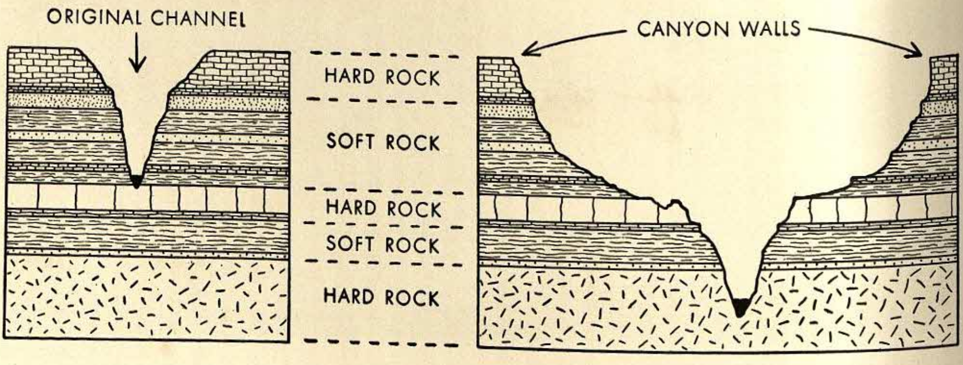
How Water Carves Caves and Canyons

Millions of years ago a stream began cutting a channel for itself. At that time the stream was unnamed, and so were the mountains in which it had its source. Day by day and little by little through the ages, it continued its work. Its chief tools were the bits of sand and gravel it carried in its moving water, and its helpers were the rains and snows of the mountains.

The stream had to make its way for the most part over layers of very old rock. Some of these layers were soft and some were very hard. But once a valley is cut below the water table and gains a permanent stream, the wearing away continues even through the hardest rock. In time deep gorges were developed. Today that stream which began in a small gulley is known as the Colorado River, and the steep cliffs cut by the stream form the walls of the famous Grand Canyon.

The work of the Colorado River is by no means completed. Aided by the action of rains, frost, winds, and landslides, it is still wearing away rock, and will continue to do so for many years to come. At present the brim in many places is over a mile above the stream, and the canyon 10 or 12 miles across and nearly 300 miles long.

Part of the wonder of the Grand Canyon lies in the many-colored rocks, whose varied tints range from white to deep red. As the sun moves across the sky bringing sunshine and shadow to different parts of the canyon, the visitor is held spellbound by the remarkable play of colors on the rough cliffs that make up its gigantic walls.



Formation of a canyon such as the Grand Canyon

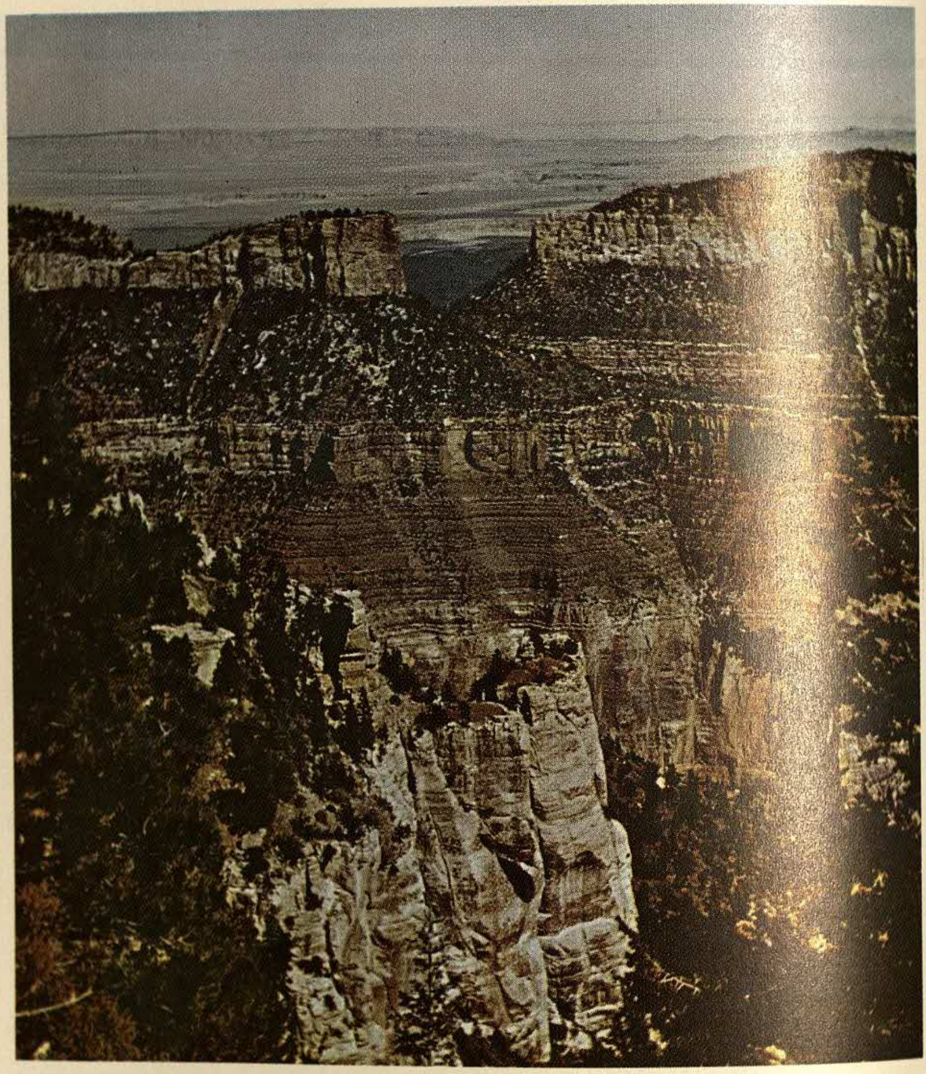
SNAKE RIVER running through canyon

Tributaries also have carved their way down through the colored rocks to join the Colorado on its way to the sea. No wonder the river itself is red with ground-up red rock through which it eats its way. Thus, it is not strange that the Spanish explorers named it the Colorado—the color of red.

Many rivers have carved deep canyons. The Snake River, which empties into the Columbia, has cut the deepest canyon in the United States where it flows between the boundaries of Idaho and Oregon. This remarkable gorge averages 5,500 feet in depth for a distance of 40 miles. The Yellowstone River in Wyoming and the Yakima River in Washington also have carved deep gorges. All these are amazing examples of what swift water can do. The towering walls remain as magnificent monuments to the rivers' ceaseless efforts.

The formation of caves is as wonderful as that of canyons. Here again, water is the sculptor, this time carving rugged chambers out of rock lying beneath the earth's surface. In its journey underground the water gathers up quantities of animal and vegetable matter. This matter, in combination with the water, forms carbonic acid which dissolves certain substances in rock much more easily than pure water does. The rock most easily dissolved by this solution of water and acid is limestone. That is why the most remarkable caves in the world are found in limestone regions.

Limestone is dissolved in much the same way as a cube of sugar is dissolved in a glass of water. Of course, the rock is not so easily dissolved as that. In fact, it takes millions of years to dissolve large deposits of limestone.



The steep cliffs of the GRAND CANYON

Limestone rock occurs in layers, sometimes several layers resting on top of each other. Rain water seeps through any small cracks and dissolves some of the rock as it runs along. As the space under the ground gets bigger and bigger, the roof over the hole may fall in, forming a sink.

If, however, the roof does not fall in as the hole grows larger, then the hole becomes a cave. Sometimes the water oozes sideways along the layers of rock and dissolves the rock in many directions.

By so doing, the water creates a network of underground passages or caverns.

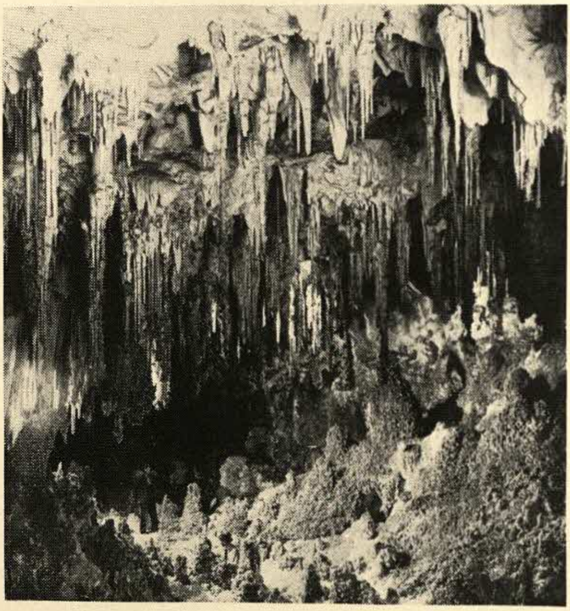
Usually the water that has trickled through the rock collects to form an underground stream. As the stream gets larger, it cuts its way lower into the rock and runs away to become a part of a surface stream outside the cave. Sometimes no stream can be seen in the floor of the cave, although one seems to be flowing out of the cave. Such a stream is called a lost river. In reality, such a river is running along in the cracks and layers of rock below the floor of the cave.

Many of the large caves are famous for beautiful rock formations, which have the appearance of huge icicles hanging from the ceilings and for the cone and needle-like shapes of the same material standing on their floors. These formations are called *stalactites* and *stalagmites.* The stalactites grow down from the ceiling and the stalagmites grow up from the floor.

Who ever heard of rocks growing? But that is just what these "icicles" of rock do, only in a special way. The water which comes trickling through the ground above the cave roof passes through the limestone rock. Upon reaching the ceiling of the cave, it begins a drop by drop journey to the water table. In so doing, it comes in contact with the air moving in the cave, which causes some of the water to evaporate. When the water evaporates, it cannot take the dissolved rock substance with it into the air. So it deposits the whitish material on the cave roof. This deposit is the beginning of a stalactite. Once a stalactite is started it keeps on growing just as a real icicle does. Its stopping place is the cave floor.

Not all the water, however, evaporates from the ceiling. Some of it drips to the cave floor. Here, too, some of the water is evaporated, and again a mite of rock substance is left behind; this time on the floor. Thus a stalagmite grows up from the floor. Hundreds of these stalactites and stalagmites may be formed in a huge cave. When such a cavern is lighted, it looks like a fairyland palace of dazzling white columns and immense stony needles.

Sometimes the water contains other minerals besides lime. These minerals produce the beautiful streaks of color which appear in the



STALACTITES are deposits that hang from the roofs of caves

stalactites and stalagmites in some caves.

Every year thousands of travelers visit caves found in the United States. Although every state has some, they are found in greater numbers in Kentucky, Tennessee, southern Indiana, Virginia, northern Florida, and New Mexico.

Mammoth Cave, Kentucky, is one of the largest caves. Here a single underground passage is more than 8 miles long. Connecting shafts make it possible to travel over 150 miles through its various passageways. Part of a regular tour for visitors is a boat trip on an underground river. There one may see fish and other creatures such as crayfish and beetles, that are entirely blind. Their ancestors have lived in this dark underground region so long that they have lost the use of their eyes.

Another famous cave is the Carlsbad Cavern in New Mexico. This cave goes down to a depth of nearly 1,000 feet. One of its rooms is a half mile long and more than 200 feet wide.

STALAGMITES are deposits formed on the floors of caves

WHAT MAKES AN EARTHQUAKE?

ONE Sunday in April, the citizens of North Bend, Washington, a small city lying at the foot of the western slope of the Cascade Mountains, were enjoying the quiet and beauty of a lovely day. Some were on their way home from church, others were at home preparing dinner, while still others were reading the Sunday newspapers.

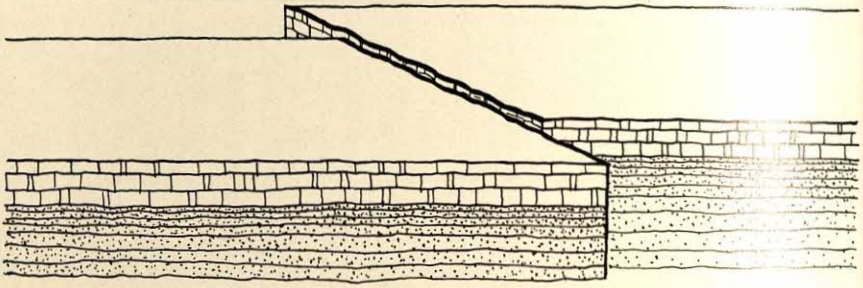
Suddenly strange things began to happen. Dishes on the tables started to slide back and forth. Pictures commenced swaying on the walls. Some objects here and there came down with a crash. Cans of food on grocery shelves toppled to the floor.

If a strange experience like this had taken place thousands of years ago, people would have considered it an act of the gods. They would have been terrified. True, many of the people in North Bend were frightened. They rushed out of their houses and gathered in groups to discuss in excited voices what they had seen and felt. What had caused the strange behavior of the dishes, the pictures, and the cans of food? The city had had an earthquake!

The same earthquake was felt a hundred miles or more from there in every direction. It was not only the people of North Bend who felt this tremor. But they had a special reason to call it their earthquake. Just outside of the city is a big heap of mountain called Mount Si. Some huge layers of rock in Mount Si had slipped and broken and that had caused the earthquake.

The rock layers that cover the earth are continually being bent and twisted by the forces in the earth. Rock layers can be bent and twisted a great deal without breaking, just as a stick can be bent without breaking. But if you bend the stick enough it will break. In the same way much force put on the rock layers causes them to break. They may snap apart quickly because they have been resisting great strains. Sometimes one part of the rock layer slips up or down along the edge of the other portion. These fractures or breaks in the rock layers of the earth are called *faults*.

When a fault occurs, it sends out shaking motions in all directions through the rock and land and water. This trembling motion is the

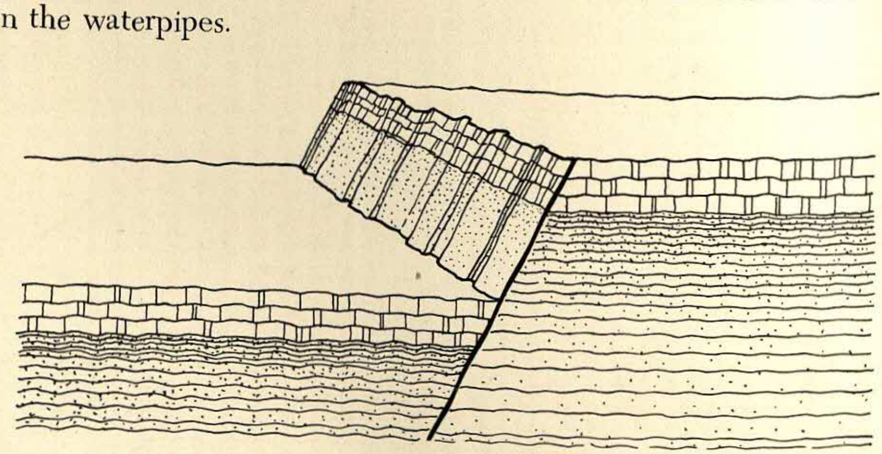


"Strike-slip" of a fault or side movement of rock layers

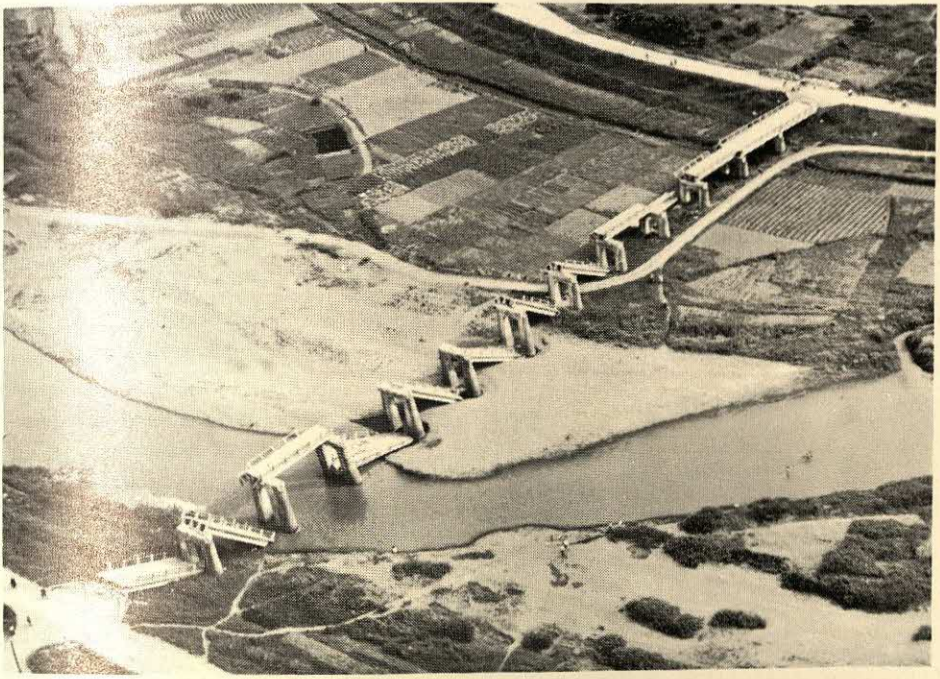
earthquake. The fault is not the *result* of the earthquake. It is the *cause.* Some earthquakes come from fresh breaks in the rock layers. Others occur as a result of an old fault just slipping or breaking some more.

The little earthquake in North Bend caused slight damage but other earthquakes have been more serious. The most destructive earthquake in the United States was at San Francisco on April 18, 1906.

The San Francisco earthquake was caused by one of the longest fractures known. Movement occurred along at least 270 miles of the fracture. In many places the earth opened up along this gap causing ditches over 20 feet in width. The fault even moved whole sections of road sideways so that the ends did not meet. Earthquakes like this may damage buildings, killing and injuring many people. Fires that often follow such destruction are difficult to control because of breaks in the waterpipes.



"Heave" and "throw" of a fault or vertical movement of rock layers



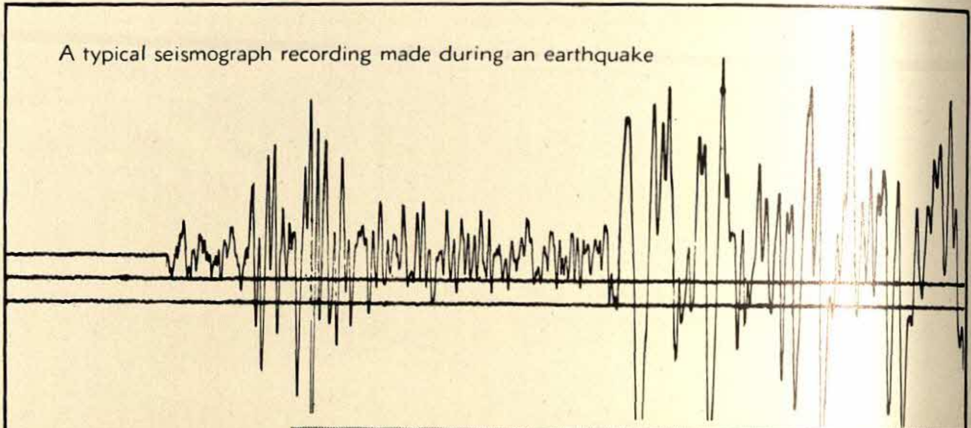
Almost every link of a concrete bridge in Japan was destroyed by an earthquake

When earthquakes occur on the floor of the ocean, huge waves are sent hurrying away in every direction. In 1946 an underwater earthquake near the Aleutian Islands off the coast of Alaska, sent out waves 40 feet high that traveled at the rate of nearly 400 miles an hour. These waves were powerful enough to cause considerable damage and the loss of over 200 lives at Hilo, Hawaii, 2,300 miles away.

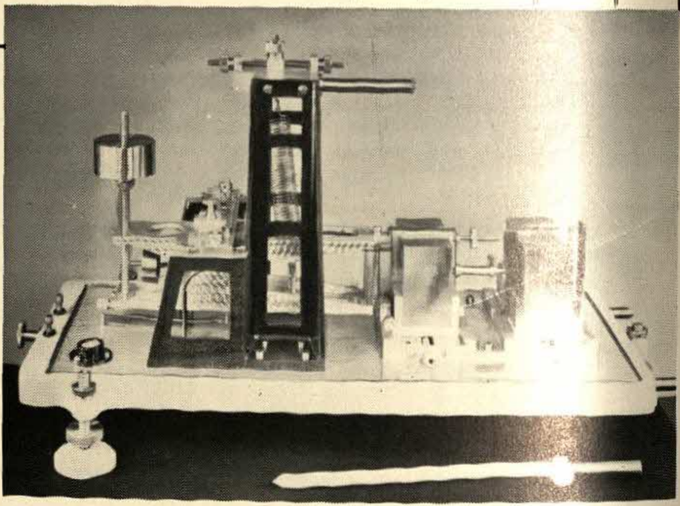
One of the worst earthquakes on record occurred in the Tokyo area of Japan in 1923 in which more than 140,000 people lost their lives. There, too, some of the damage and loss of life was caused by the huge waves that rolled in from the sea.

Fortunately many earthquakes are so slight that they are never felt. In fact, small earthquakes take place almost every day in some part of the world. Scientists have devised an instrument called a *seismograph* which keeps a record of them.

This is the way the seismograph works. If you hold a pencil lightly on a piece of paper with one hand and pull the paper straight forward with the other hand, you draw a straight line on the paper. But if you pull the paper forward and wiggle it sideways, too, then you get



A typical seismograph recording made during an earthquake



A seismograph records direction, intensity, and length of earthquakes

a crooked line. The more you wiggle the paper the more crooked the line becomes.

The base of a seismograph, containing a slowly moving roll of paper, is fastened to the deep bed rock of the earth so that it shakes whenever the crust of the earth shakes. A pencil or some marking device suspended above traces a line on the paper. Whenever a crooked line appears, it means the bed rock has been shaken. A seismograph even registers tremors that are too faint to be felt by people.

Man cannot control the forces in the earth's crust. However, we should not fear future earthquakes. Serious ones very seldom occur. Moreover, well-built buildings are not usually damaged much by earthquakes.

PROTECTING OUR RESOURCES

WHEN the white settlers first began moving westward across the United States, they were amazed by the richness of the country. They moved so slowly on foot, on horseback, or by wagon, that the great forests which stretched out across the eastern part of the country seemed endless. Wild life was plentiful. The streams and lakes were full of fish. Coming at last to mile after mile of prairie land, they were delighted with the rich soil they found when they turned up the thick sod with their plows.

The idea grew in men's minds that the new land was filled with unlimited treasure; that there was more natural wealth than could ever be used. So when the pioneers wanted to clear land for farming, they burned away the trees. If the fire got out of control and swept for miles, they did not care. When they wanted buffalo hides, they killed the buffaloes and stripped off their skins, often leaving the meat to rot on the ground. When the fish in a lake became scarce, the fishermen moved on to another lake.

Little by little, as more and more people spread across the country, the results of this terrible waste became clear. Wild turkeys, once

Unwise use of land changes fertile grassland into wind-swept sandy dunes abundant, became fewer and fewer, and the hunters learned that there were no other flocks to be found. The great herds of buffalo dwindled away until but a few animals were left. The eastern forests were stripped of their timber and in many places the cutting of the trees allowed the rain to wash away the soil, so that trees could never grow again. Many streams became filled with the refuse of cities and factories so that fish could not live in them.

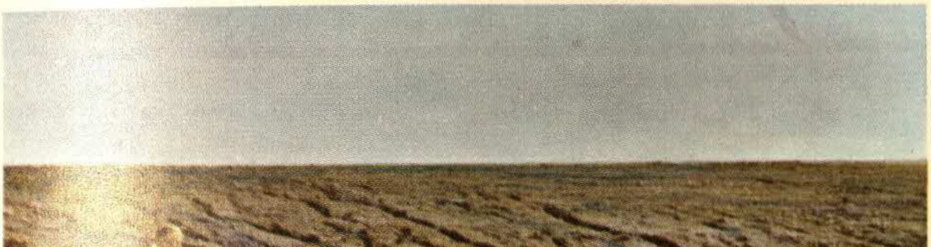
Too late, people began to find out that some things had been destroyed forever. The beautiful passenger pigeons, once found in great flocks, had all been killed by the hunters. Pasture land in some places had been ruined by allowing too many cattle to graze on it. Many mines had been improperly developed in order to remove the richest parts first, so that caving in and flooding prevented further work. Many things, once plentiful and inexpensive, either could no longer be obtained, or else they cost a great deal of money.

Fortunately, about 60 years ago, some people began to realize that the waste must stop and that we should carefully examine our natural wealth to see what could be saved, what could be replaced, and what could be developed. President Theodore Roosevelt was among the first to awaken the people to this need.

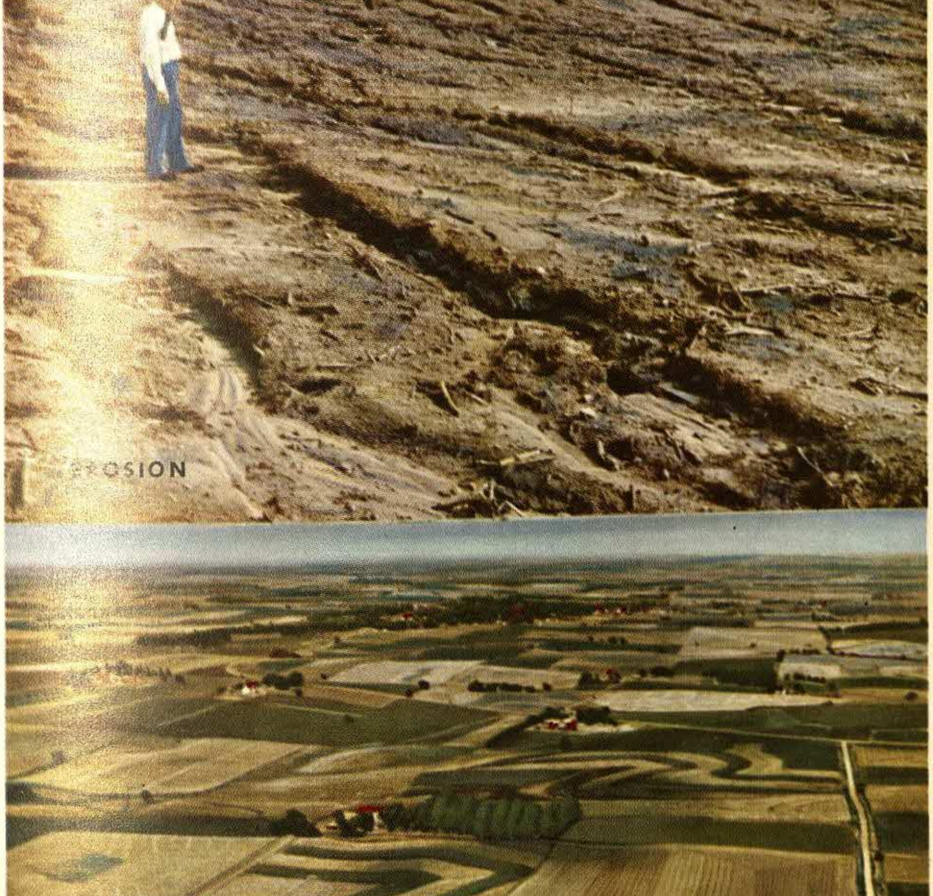
Those studying the problems of conservation know that because there are many different kinds of natural resources, different ways are required to save them. Minerals, such as iron, coal, oil, gold, and silver deposited in the earth's crust millions of years ago, cannot be replaced; all we can do is to prevent further waste in using them. The supply of fish and other wild life can be built up by careful restocking and by protective laws. Forests can be replanted so that by careful use they will always fill our needs.

Soil, which is probably our greatest single wealth, is like minerals in one way and like forests in another. Where the soil has been allowed to wear away, new soil may never form. Even under the best conditions, it takes many, many years to build it up. However, by careful scientific farming soils can be used which would be worn away by ignorant or careless methods.

In some places, after the forests were cut away or after the sod of the plains was turned up by the plow, water and wind soon began to



EROSION



CONTOUR FARMING

* * *

Plowing in straight rows, whether up or down hill causes the soil to wash away. Even in the early days of our country men like Jefferson, Madison, and Washington understood this. They plowed horizontally, following the curvature of the land. They knew this made every furrow act as a reservoir to receive and keep the water for the benefit of growing plants instead of running off into a stream.

These men, also, knew the value of strip cropping and the rotation of crops. Unfortunately too many did not know, or did not care. Consequently there has been a tremendous waste of land.

This picture shows both the waste and the conservation of land. In the upper section, an Iowa conservation worker notes the waste caused by up and down hill planting of a cornfield. The lower half shows how the practice of contour plowing and strip cropping has checked erosion and helped to preserve some of Iowa's most productive farm land.

* * *

WISCONSIN CONSERVATION DEPARTMENT

carry away the soil that had been held in place by tree or grass roots. By replanting the forests, and by changing many of the plowed fields back into pasture land, we can prevent further erosion. Since the soil is carried away faster on hillsides where water runs rapidly, it helps immensely to plow the furrows around the hills, instead of across them. This is called contour farming.

Thus, there are two main ways of preventing soil from being washed away. One is to make the soil more difficult to move, by using plants of one kind or another to hold it in place. The other is to reduce the speed of the water moving across the soil, so that the soil, even if loose, will not be carried away. For a long time there were many people who could see only one side of the problem; today we know that both methods should be used together.

There is still much waste and much that needs to be done to prevent it. Often people do not know how to take care of their soil or their forests or their minerals. Sometimes they are selfish and do not care, taking what they can get for themselves, without considering their neighbors or others who come later.

A forest of great beauty and wealth . . .

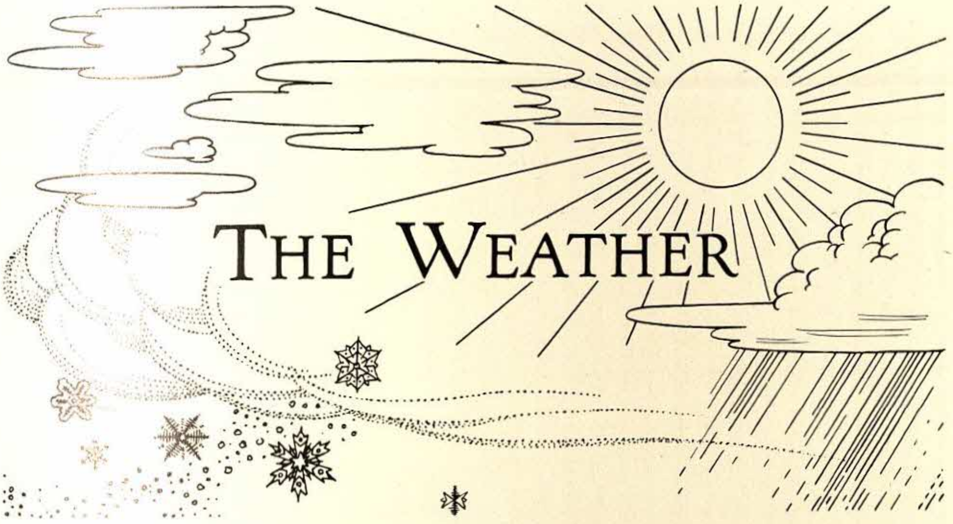
But daily more people are learning the importance of conservation. The saving of natural resources really means many things; it means preventing waste; it means replacing things as they are used up whenever it is possible; it means searching for new sources of materials; and it means striving to find new materials which will serve the purposes of the old.

Huge areas richly endowed by nature with natural resources as well as with beautiful scenery have been set aside as national parks, and there are other parks and preserves all over America. Forest ranger stations throughout our timbered areas help to guard against destructive forest fires. Governmental agencies are co-operating with farmers and people in many other occupations to help preserve our natural wealth. Numerous clubs and private organizations are helping in the work. In many youth organizations, such as the Boy Scouts, Girl Scouts, Camp Fire Girls, and 4-H Clubs, conservation is part of the work and training of the members.

If the United States is to keep its important place in world leadership, we must do everything we can to protect the resources which have made us a great rich country.

. . . turned into wasteland by fire

THE WEATHER



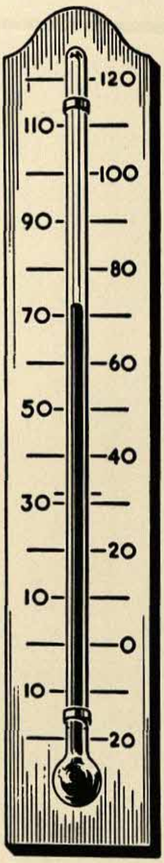
HOW THE WEATHER AFFECTS US ALL

YOU wake up some morning and it is raining. If the skies have been clear for several days and you have not read the late weather forecast, you are quite surprised at the change. If you are planning to do something out-of-doors, you are disappointed. Something has happened to the weather. Perhaps your program for the day or some part of it has to be changed.

A successful picnic or outing at the beach requires fair weather. The farmer needs a certain amount of sunshine and rain during his growing season but prefers very dry weather when he is ready to harvest his crops. The sailor depends on the right wind to sail his ship, and he is in trouble if he encounters a storm. The aviator must have good weather or it is not safe for him to fly.

In the earliest times people looked to the heavenly bodies as the givers of all things good and bad, including the weather. Of course, they were right about the sun making our weather. It does so more fully than they could have realized. They were wrong in thinking that the moon, planets, or stars had anything to do with it.

People also used to watch certain signs in nature to tell what the weather was going to be like. If in the fall the animals seemed to be getting an extra heavy coat of fur, the people thought it meant that a



Thermometer

very cold winter was on the way. When ants traveled in lines, a fair day was ahead. There were many such beliefs that were based largely on guesswork or superstition.

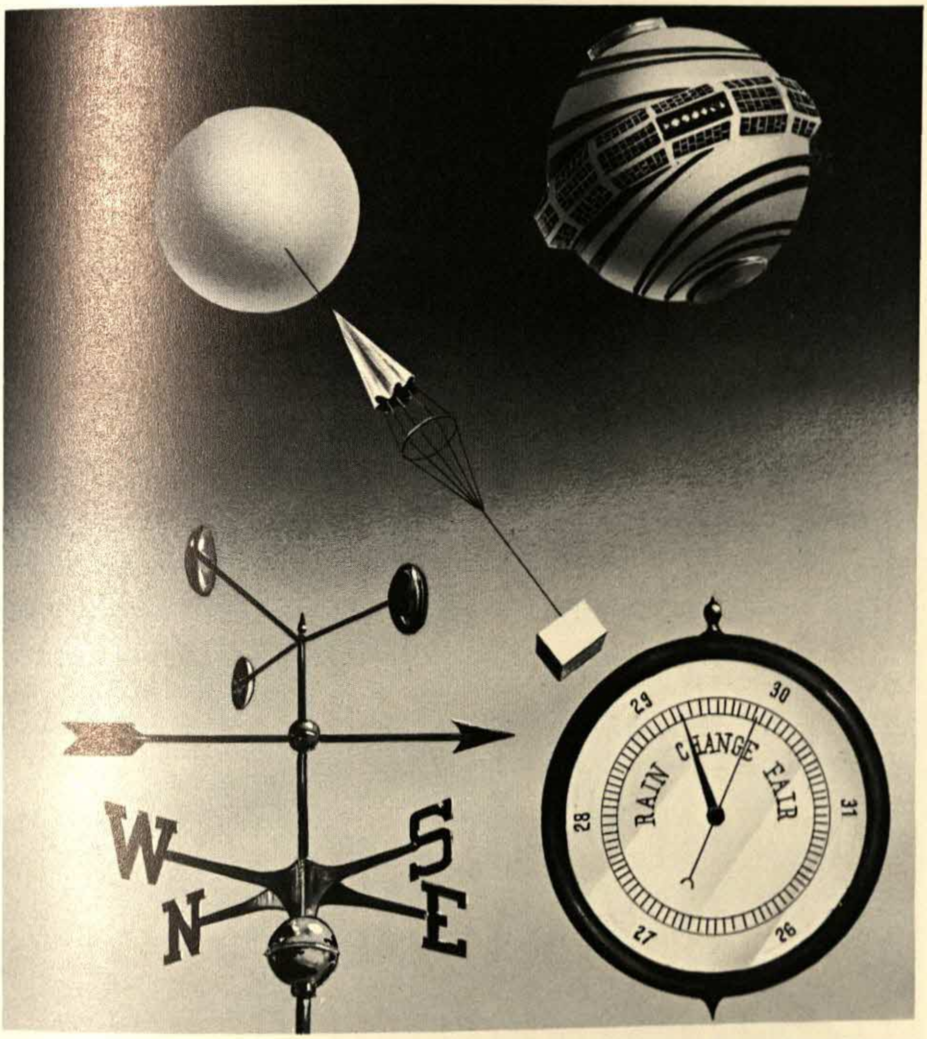
Gradually other signs were discovered that really did have a great deal of truth to them. Before storms, sounds could be heard at a greater distance. When smoke rose straight up, rain would not come soon. If in hot weather a pitcher of cold water gathered many beads of water like perspiration on the outside, people said rain was coming. They would often be right. Such signs at least indicate whether the air is dry or moist, and that has a lot to do with the weather.

The noted Italian scientist Galileo was the first to make an exact science of the study of the weather. One of the important things he did was to invent a thermometer. Although the thermometer can *record* temperatures, it gives no hint as to what weather may be on the way. In 1643 Torricelli, a pupil of Galileo, invented the barometer, an important instrument in *predicting* the weather.

The barometer helps to tell what kind of weather is coming by showing how heavy or light the air is. Moist air, which brings us our stormy weather, is somewhat lighter than dry air. Therefore when the air is moist, the pressure on the barometer is less and the reading is lower. When the barometer is low or falling rapidly, we can be reasonably sure that a storm is on the way.

On the other hand, when the barometer is high or rising steadily, it means the air is dry and we can usually count on fair weather for the next twelve hours at least.

However, there are other things which act on the weather which the barometer does not record. The modern "weatherman" has an expert knowledge of what makes weather and relies on a wide variety of instruments to carry on his work. One of his newest tools is the weather satellite, and such satellites are now whirling in orbit around



Four weather instruments: top left, weather balloon; top right, weather satellite; bottom left, anemometer and wind vane; bottom right, barometer

the earth—taking photographs of the clouds. These photographs give us a broad picture of weather movements around the world.

We are familiar with the daily forecasts of the weather bureau because they are readily available in the newspapers and on television and radio.

The three basic elements which create weather may be listed as heat, moisture, and wind. Weather is heat, moisture, and wind combined. Let's find out more about the three great weather-makers, beginning with heat.

HEAT AND SUNLIGHT

When you walk barefooted on a hot sandy beach, your feet feel hot. This is because of the heat in the sand. Where does the heat come from? From the sun, of course. The sun gives all of the heat for all the weather in the world. The weather is hot when a considerable amount of sunlight makes it so; the weather is cold when there is less sunlight. We have already seen in the section "Earth and Sky" how the temperature varies during the day because of the angle from which we receive the sun's rays.

Also we have read how the angle at which sunlight comes to us is responsible for the seasons of the year.

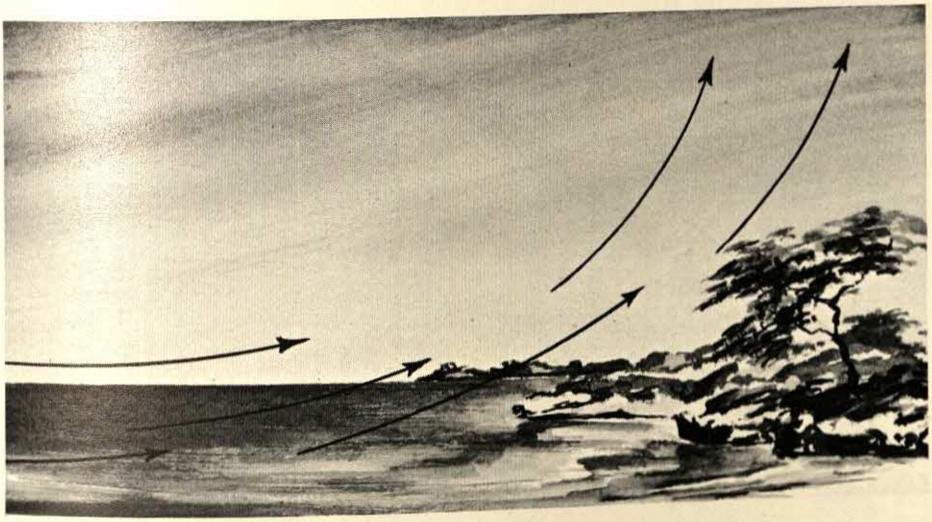
Without heat it would not be possible for us to live on the earth and plants would not grow. The earth would be nothing more than a barren mass of rock rushing through space. Many other planets, farther from the sun, are too cold for human beings. For example, the temperature of Pluto—which receives little light from the sun—is about 380 degrees below zero.

However, too much heat can be harmful. Unless we are careful not to work or play too hard on a hot summer's day, we may collapse from heat exhaustion or sunstroke. In addition, excessive heat can damage crops and can dry out the leaves of trees and brush, so that it is easy for them to catch fire.

THE WIND AND ITS WORK

ANY BOY or girl who has ever flown a kite or watched a windmill turning in the breeze knows some of the things that the wind can do. Did you ever wonder what causes the wind? It is mainly the sun.

Even though the sun may not be shining where we are, it is always shining in many places over the earth. Where the sun shines it heats up the land and the air over it. Warm air, being lighter than cold air, rises. Where the air rises, cooler air around it rushes in to take its place. At the shore of a large body of water we often feel a cool breeze coming in off the water during a hot, sunny day. The cool air is taking the place of the warmer air that is rising above the land. Then at night the land cools off faster than the water so that the breeze usually goes the other way.



These differences in the way the sun warms the air in numerous places help to keep the air moving most of the time. We have upward and downward currents of air which we do not notice unless we happen to be flying in an airplane; and we have the movements of air along the surface of the earth which we call wind.

Sometimes these air movements are mild and cover just a small

EXAMPLES OF WIND FORCE AT DIFFERENT VELOCITIES*

LIGHT
(1 to 7 miles per hour)

Slow smoke drift. Wind felt on face. Leaves rustle.

GENTLE
(8 to 12 miles per hour)

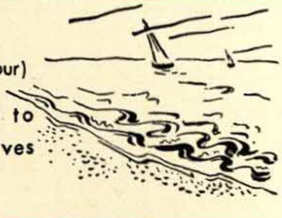
Flag waves. Leaves and small twigs in constant motion.

MODERATE
(13 to 18 miles per hour)

Raises dust and loose paper Small branches sway.

FRESH
(19 to 24 miles per hour)

Small trees start to sway. Crested waves form on lakes.



STRONG
(25 to 38 miles per hour)

Whole trees in motion. Umbrellas used with much difficulty.

GALE
(39 to 75 miles per hour)

Great difficulty in walking. Trees uprooted. Buildings damaged.

*Adapted from Beaufort Scale of Wind Force, U.S. Weather Bureau

area, but more often they are part of a large movement of air covering hundreds of miles.

We cannot see the wind but we can feel it and see the effects of it. We can see dust and other objects that it carries. We can see a flag waving in the breeze and wet clothes on a line being whipped back and forth by it. We can see tree leaves shaking and branches swaying. We can see a hat blowing down the street and we know that it was the wind that took it off the owner's head.

Perhaps few people have ever stopped to think how many useful things the wind does for us. The wind brings our changes of weather. It brings us rains to water our gardens and farms, and it blows the clouds away to give us sunshine again. It scatters seeds far and wide so that plants grow in new places. In summer it helps to keep us cool. It makes waves on the water and dries our wet bathing suits. It turns windmills; it sails boats. In the days before steam engines were invented, people depended on sailing vessels to make long journeys by water. Columbus could not have discovered America if there had been no wind to push the sails on his ships.

But the wind at times can make us quite uncomfortable and can do much damage. When the air is cold, the wind makes it feel still colder. Wind sometimes causes shipwrecks. It blows down houses and trees. In some sections of the country, it blows away the rich topsoil from the land. It fans forest fires and often causes big areas of timber to be destroyed before the fire can be controlled.

In the central part of the United States, occasionally there appears a twister or whirlwind which is often called a cyclone, although its correct name is tornado. During a tornado, which has black funnel-shaped cloud at its center, houses and even people are sometimes picked up and carried blocks away. Thunderstorms without this violent whirlwind center are quite common, but such storms usually are not very destructive.

Tornado

Hurricane

The sands of a dune shift all the time

On some parts of the earth, there are occasionally severe storms during which the wind is very strong, even blowing at the rate of one hundred miles or more an hour. In the southeastern part of the United States and in the West Indies a storm like this is called a hurricane.

In the region around the coast of China the same type of storm is called a typhoon.

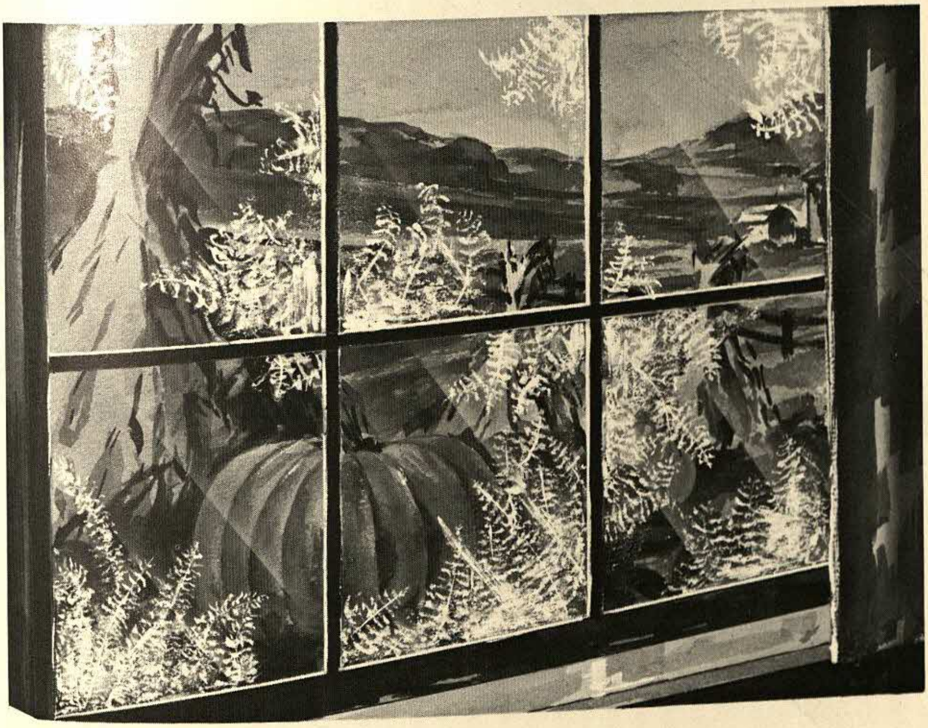
Winds are continually making changes on the surface of the earth. Next to running water, wind is the greatest force in moving soil. It cuts down hills, the sand that it carries scouring and helping to wear away the rocks. It fills in some valleys and deepens others. Sometimes on the shore of a large body of water the wind piles up big hills of sand called sand dunes.

The sands of the deserts are shifting all the time. In the Gobi desert, in Asia, there are ancient cities which lie buried under heaps of sand piled up over them by the wind.

MOISTURE IN THE AIR

Often when we go outdoors in the morning we find the grass covered with small droplets of water. We say the grass is covered with dew, and perhaps we wonder how it got there. Dew does not fall like rain. It is water formed from moisture in the air which condenses on contact with the cool grass and other things on the ground. During the night, the ground gives off—or radiates—heat very quickly. Therefore, the ground, and things on the ground, can become quite cool. If moist air is present, and there is no strong wind, dew will result. We may find it on the bare ground, on the grass and other plants, and on all of the cool items resting on the ground.

In autumn and spring, we occasionally observe dew that has become frost. The ground has lost so much heat during the night that plants and other things on the ground are below the freezing point. Moist air will then freeze on touching them. Frost is composed of the same delicate ice crystals that we find in snow and very much resembles snow. But it does not descend from the sky as snowflakes do.



Condensed moisture from the air collects on pitcher of cold water

All air contains water vapor, including the air in our houses and schoolrooms and the air out-of-doors. Sometimes there is only a little water vapor, and sometimes there is a lot. Air that contains much water vapor is said to be "humid." We are uncomfortable if the air is very humid and warm at the same time.

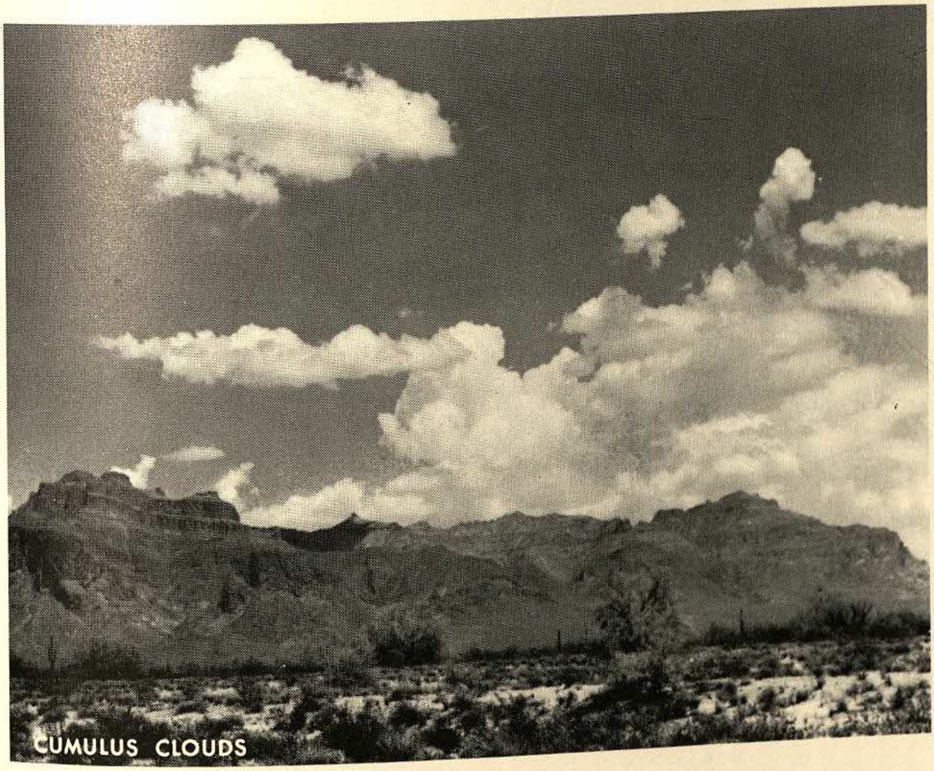
We cannot see water vapor because it is an invisible gas. But if we cool some moist air, the molecules of water will cling together, or condense, so that droplets are formed. You can make an experiment to show that water vapor is present and ready to become a liquid. Simply place a glass of ice water in a warm room. The chilly glass will cool the surrounding air and soon small drops will appear on the outside of the glass. The drops do not come from the water within the tumbler, for water cannot soak through glass. They come from water vapor molecules condensed from the air.

This is very much the way raindrops are formed. As warm air rises high into the sky it becomes cooler and begins to condense. High-altitude masses of tiny droplets, which we call clouds, result. The droplets actually build up around tiny specks of dust in the air. As more and more water clings to a dust particle, a droplet becomes heavier. Eventually, it will be so heavy that it cannot stay in the cloud any longer, and down to earth it will fall.

Hail is frozen rain which occasionally falls during the warm season. Hail is formed in an interesting manner. Raindrops start to fall from a cloud and then an upward gust of wind blows them back into the cloud again. Up and down the raindrops go, and all the time the cold air is freezing them. Finally they leave the cloud in the form of frozen balls of ice. Hailstones sometimes damage gardens and crops.

There are many types of clouds. Some are much higher than others, some are more likely to produce rain. The light fleecy ones usually are not more than a mile from the ground. These clouds are often flat at the bottom and rise into what appear to be big fluffy mountains. Scientists call clouds like this "cumulus" clouds. Cumulus means "a heap." They are the fair-weather clouds. When we see them floating like huge pillows through the blue sky, we know that we will have a bright and fair day. It is only when they turn black in becoming more dense that rain falls from them.

The clouds that normally bring us our rain are called "stratus" clouds. Stratus means "a layer." Sometimes these clouds are on top of one another like a layer cake. Sometimes they are strung out like a piece of taffy candy being pulled. When the layer of clouds is so thick that it blots out the sun, we have gray days. Often a drizzly



CUMULUS CLOUDS

rain falls. Stratus clouds are very near the earth. Sometimes they are so close to the ground that we walk right through them. Then we call them fog. In many places, especially along the seacoast, fogs are very common.

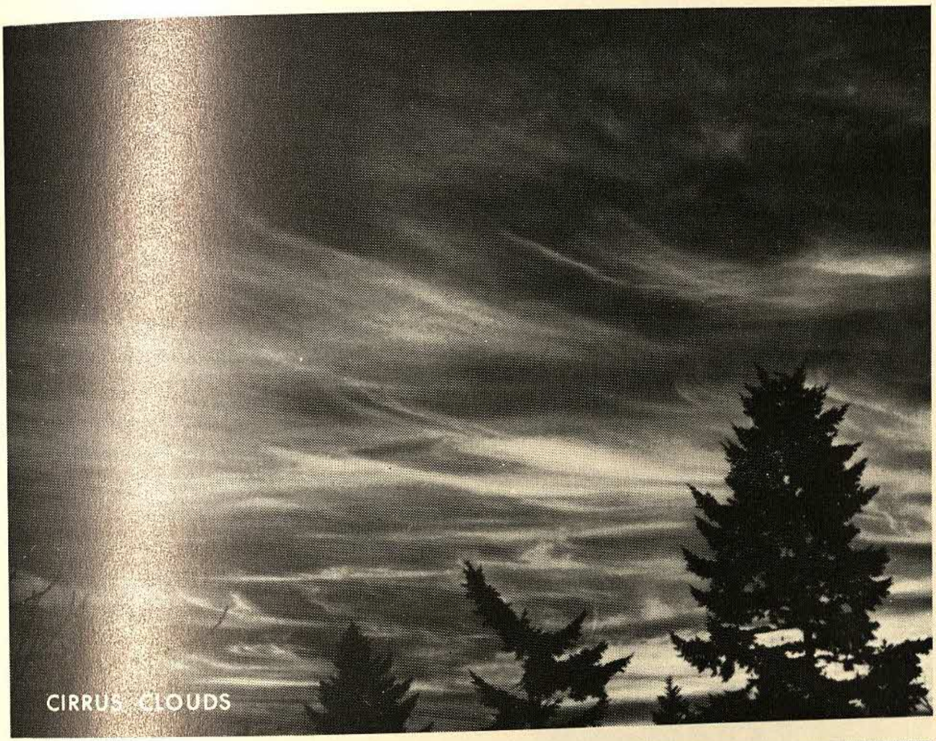
Fog often occurs around cities because the smoke and extra dust helps the water vapor to condense. When the air is full of moisture, usually all that is needed for fog to appear is just a small decline in the temperature. If the air becomes still colder, the fog will often turn to rain. If the temperature goes up again, the fog will turn back to vapor and disappear. Sometimes a wind may blow fog away.

STRATUS CLOUDS

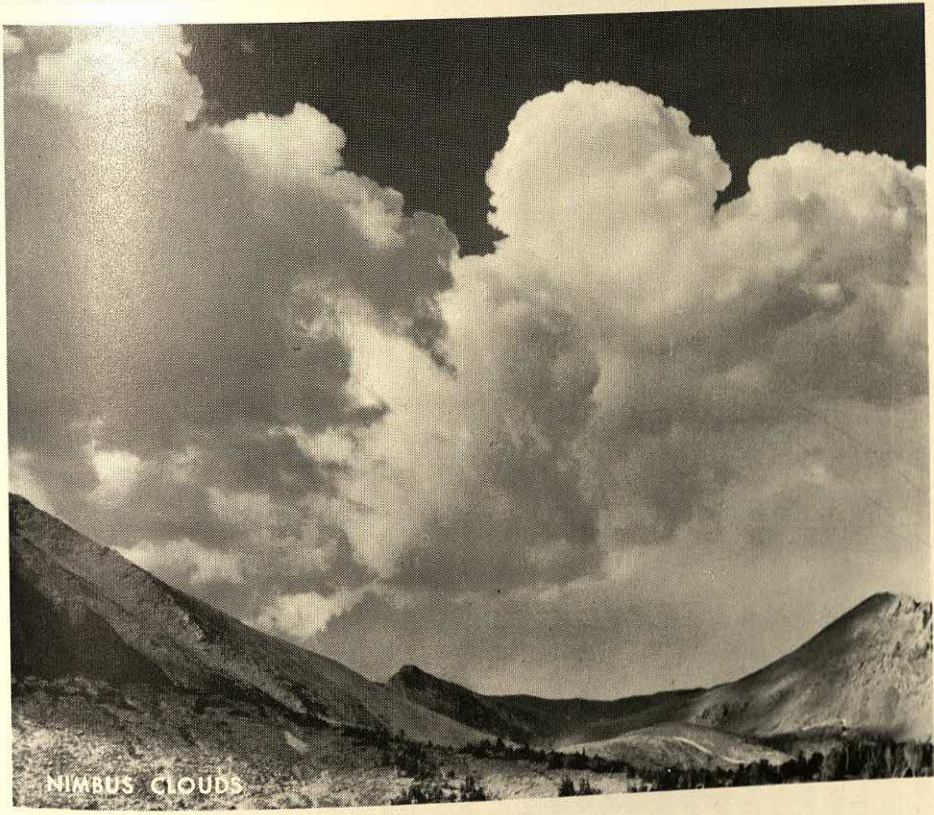
Fog slows up traffic and causes accidents on land and sea, but it is in air travel that it is most troublesome. While aviators can fly through fog or over it, they do not like to land in it. Many ships at sea have bumped into each other because of fog.

Now, however, radar, an instrument which tells when we are approaching another object even though we cannot see it, is overcoming these problems.

Another kind of cloud that we see very often is the "cirrus" cloud.



CIRRUS CLOUDS



NIMBUS CLOUDS

Cirrus means "curl."

Cirrus clouds are farthest from the earth, from six to ten miles up. Because of the cold weather at high altitudes, they are filled with ice crystals. They look like curled white feathers floating across the sky. Sometimes they move slowly and that means that the day will be fair.

When the cirrus clouds move swiftly, it usually means that the day will become colder.

There is another kind of cloud that we ought to know about and that is the "nimbus" cloud. Nimbus means "rainstorm."

This really is a rainmaker! It is dark and heavy-looking and low in the sky. It is likely to bring a hard rain, although it may not last long.

The darker the cloud, the larger the drops, and the nearer the rain is. The light cumulus clouds do not bring rain, as long as they remain light and fluffy.

The gray stratus clouds usually do bring rain, especially if the air gets cooler. But the nimbus clouds are already sending down rain. Nimbus clouds always accompany thunderstorms.

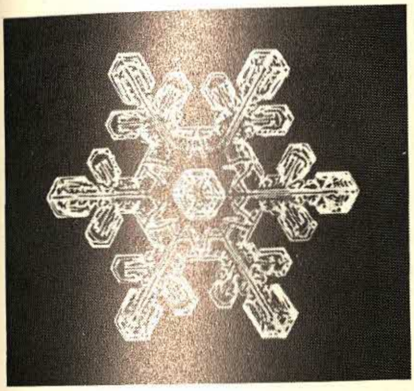
We are impressed by thunderstorms because they are spectacular. Of course, the thunder itself does no harm, but the lightning which shoots from the darkened clouds can be very dangerous, for its electricity can cause serious fires.

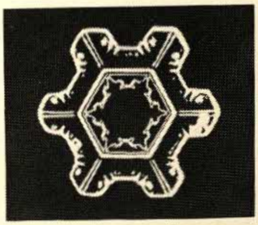
Lightning—a huge electric spark

No one should stand under a tree during such a storm because lightning often will strike a tree.

Scientists do not know for sure what makes lightning, but they do know that it is a huge electric spark.

Benjamin Franklin discovered that lightning was a form of electricity about two hundred years ago while flying a kite in a thunderstorm.





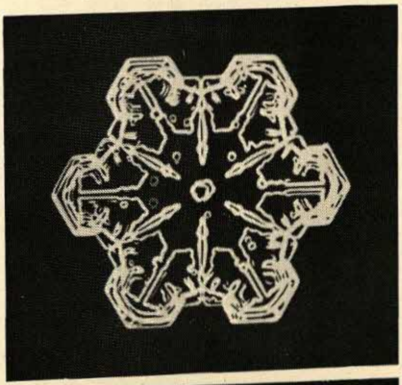
SNOWFLAKES AND ICE

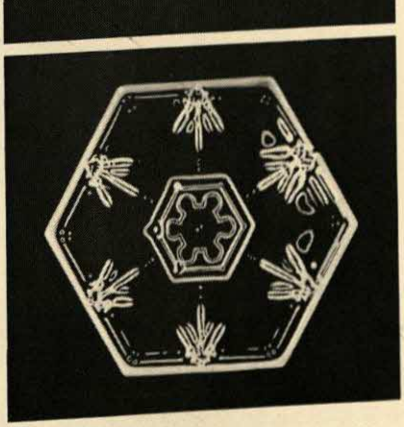
Children who live where snow never falls or where the ponds and lakes never freeze miss some very exciting adventures. Snow battles, ice skating, and sleigh-ride parties are some of the sports that children in the North can look forward to every winter.

Snowflakes are several ice crystals that have joined together. In winter, the water vapor in the cold clouds has turned into ice crystals instead of rain. As in the formation of raindrops, ice crystals fasten onto dust specks. One crystal fastens to another and, when many of them are joined together, they become a snowflake and are heavy enough to fall from the cloud.

The snowflake usually stays frozen when it hits the earth, because the air around the earth is cold in winter.

Sometimes, though, snowflakes melt or are broken on their way down to earth.





We see crystals every day when we look at salt or sugar, but ice crystals are different. They are not smooth and solid like sugar or salt. Ice crystals have six sides and are in beautiful star shapes and flower designs.

No two crystals exactly alike have ever been found. One must look at snow crystals through a magnifying glass in order to see the delicate patterns clearly.

As the soft snowflakes come down to the earth and pile on top of others, some air is left between them so that all outdoors looks as though it were covered with a fluffy white blanket. We look at it and think we have never seen a more beautiful sight. But this beautiful snow can become quite a nuisance, too. Often the wind blows it into huge drifts that block highways and railroad tracks so that they have to be opened by snowplows. Sometimes snow and ice break down telephone lines and trees. Snow on a roof may get so heavy that the roof caves in.

In some parts of the country, as in Minnesota and the Dakotas, such severe blizzards sometimes occur that people have to be careful not to get lost in them.

Traffic practically stops at these times and schools close for a day or two until the storm is over.

When the temperature of the air gets down below 32 degrees, the top layer of water in ponds and lakes begins to freeze into ice crystals. The crystals are somewhat like those that are formed in snow clouds and they have six sides. These stick together and make a coat of ice that floats on top of the water. The ice coat gets thicker as the cold weather continues. The ice always freezes from the top down. When the ice on a pond has frozen far enough down so that it will hold the weight of several people, it is usually safe for ice skating.

Winter gives the plants and many of the animals a rest. Snow helps to keep the earth warm and filled with moisture. It is good for the plants that are buried underneath.

In the spring when the snow melts, some of it soaks into the earth and some of it flows into streams to provide water for fish, for boats, and for many other uses.

CONTROLLING THE WEATHER

As we learn more and more about the weather, we are constantly thinking how nice it would be to control it. We may someday be able to determine our weather merely by pushing a series of buttons. But even now we have developed a small measure of control over some aspects of weather such as rain, hail, and frost.

We have found that we can bring about rain with a process called "seeding" the clouds. This has not yet proved very practical because seeding is expensive, but there is hope of reducing the cost in the future. In seeding, small pellets of a very cold substance—such as "dry ice"—are scattered from an aircraft flying over a cloud.

Dry ice is made from the gas we find in the air called carbon dioxide. The pellets of dry ice, in passing through the cloud, will cause the cloud's tiny droplets of water to join, creating larger droplets. When the drops are heavy enough—as we have read—they descend as rain.

As early as the 17th century, a method of preventing hail was discovered. If a cannon is fired into the sky, the shock will interrupt the up-and-down cycle of air currents whereby hailstones are formed. The shock of a bursting rocket also will have this effect.

Like the artificial formation of raindrops, the shock method of fore-

stalling hail still is not economically sound. At present we cannot afford to prevent hail on a wide scale.

Thus far, perhaps our most successful venture in controlling the weather involves the prevention of frost. Frost is formed when the moisture in the air freezes upon touching the cool ground. Certain crops, such as fruit trees, can be killed by frost. But if the ground and the plants are kept warm the moisture cannot freeze and frost will not form.

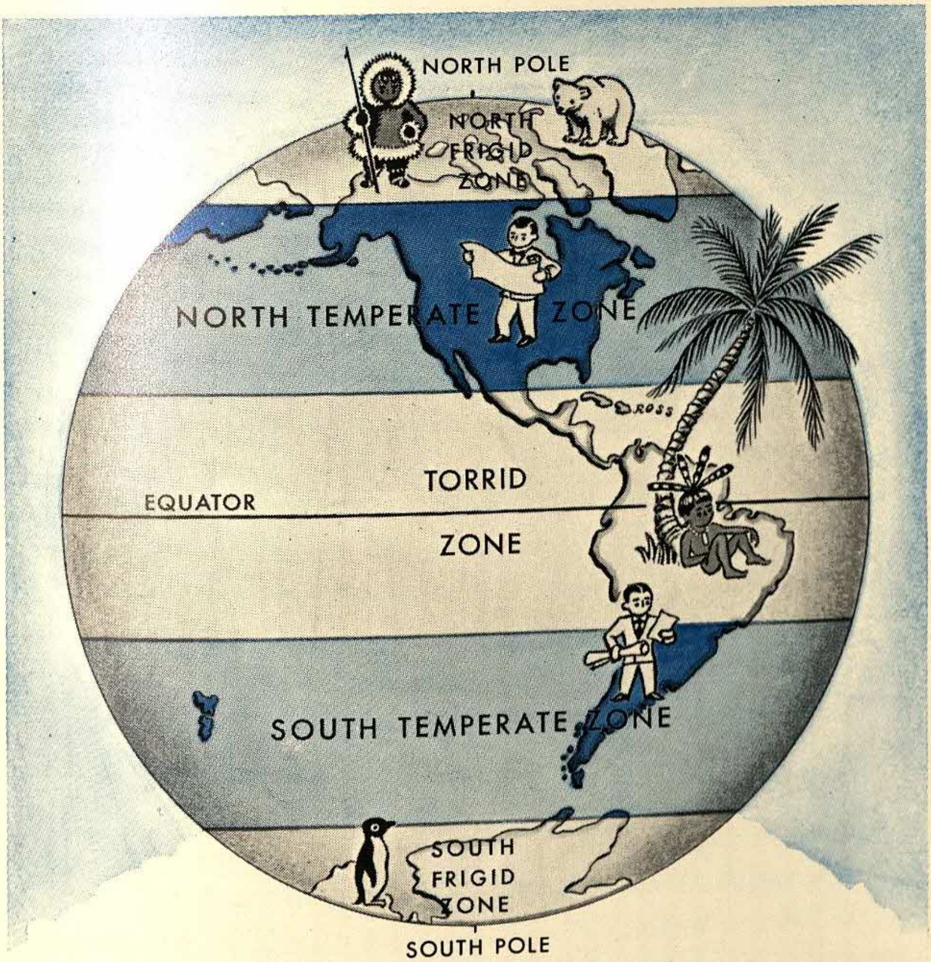
This warmth can be achieved by covering the crop with straw or with an artificial cloud of water vapor. The artificial cloud can be created by burning a very smokey fuel or by use of chemical smoke.

In the fruit orchards of the South, the burning of an oily substance in a smudge pot makes an artificial cloud that holds the warm air down among the trees.

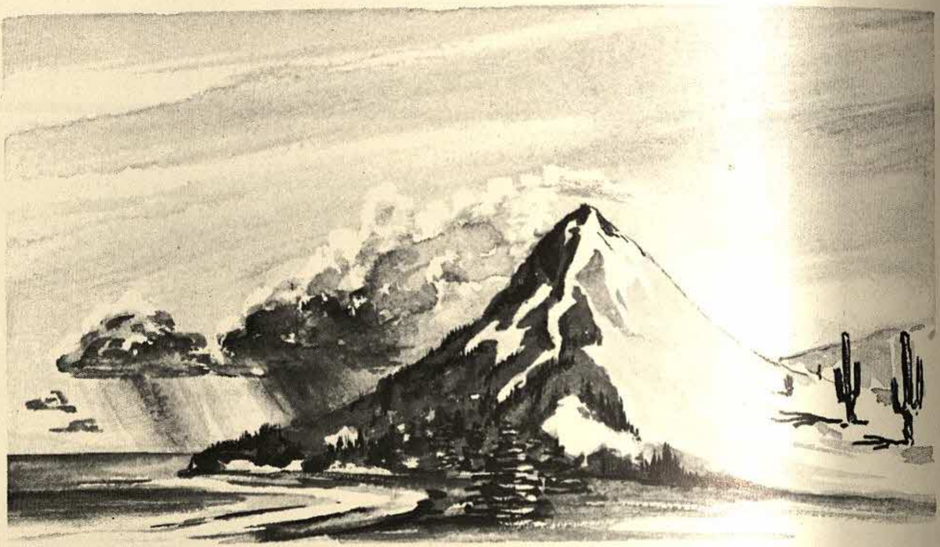
CLIMATE

The weather is never the same all over the world. While one part of it is having rain, another may be having sunshine. Some areas are much warmer than others. In the parts of the world where the sun is more directly overhead the climate is warmer than in places where the sun does not climb as high in the sky.

Climate is the word we use to express the usual or average kind of weather for an area. If the temperature is usually high, we say that the climate is hot. If there is usually much rain, we say that such a place has a wet or rainy climate.



Map showing zones of temperature



As the clouds travel up over the mountain they lose their moisture on the way, creating a damp climate on one side and leaving the other side arid and dry

In the United States the hottest weather on record occurred in Death Valley, California, on July 10, 1913. The temperature was 134 degrees! The coldest weather occurred in Rogers Pass, Montana, on January 20, 1954, when the temperature was 70 degrees below zero. The wettest climate is in western Washington, and the driest is in southwestern Arizona and the adjoining part of California.

Temperature, of course, depends mainly but not entirely on the season or the distance from the equator. Sometimes there are other things that influence temperature a great deal. For instance, high mountain peaks can be very cold even in the hot belt. The coast of northern Norway has a fairly mild climate even though it is quite near the North Pole because the warm waters of the Gulf Stream come close to its shores.

There are sometimes dry regions not far from places that have a heavy rainfall. This may be due to mountain ranges in between. Western Washington has a great deal of rain because, as the rain clouds blow in from the ocean, they are forced up high above the Cascade mountains. This cools the clouds and causes the rain to fall. The clouds that do move on have lost most of their moisture, and the land to the east of the mountains get very little rain. Here the farmers have to irrigate the land in order to raise crops.

Quito, the capital of Ecuador in South America, has the most even temperature of any city in the world. Although it is only fifteen miles from the equator, it is over nine thousand feet above sea level —which gives its temperature such an even balance that it is always like spring there. Its warmest month averages only about 1 degree warmer than its coldest. On the other hand, Bismarck, the capital of North Dakota, has a wide variety of temperatures. Its average for January is 8 degrees and for July 70 degrees, a difference of 62 degrees. In fact, it has been known to get as cold as 45 degrees below zero there and as hot as 114 degrees above, a difference of 159 degrees.

In most of the lowlands of the hot belt near the equator, winter and summer are much the same. It is always hot. Therefore, the people there do not have the seasons we have. In most of these hot lowlands there is a wet and a dry season, or perhaps a wet season and one not quite so wet, because there is always plenty of rain.

Near the North and South Poles there are two or three months of summer when the sun stays in the sky both day and night, and there is an equal time in the winter when the sun does not shine at all. Except in the short summer, the weather is very cold and nothing can grow except a little moss.

Climate influences the life of every living thing—animals and plants as well as people. In the winter some birds that live in the North migrate, or make long journeys to warmer lands. Many plants cannot live except in a warm climate and few can survive without a fair amount of rainfall. The only land animals that can exist in the cold polar regions are those with very heavy fur. It is the climate of a place that determines the kind of life there.

Near the equator, with plenty of fruits and other plants growing all through the year, people do not have much trouble getting food. They need very little clothing and no fuel to keep warm. They do not need to do a great deal of work in order to live. It is too hot to work hard and even when they walk they move slowly.

Think how different it is for the Lapps and the Eskimos who live in the far north. They must hunt and fish and tend the reindeer constantly. They have no fruit or vegetables, because it is too cold for them to grow. These people must have furs for warm clothing.

They need fuel and they need good shelter to protect them from the winter winds. Much of their time is spent in getting the things they must have in order to exist.

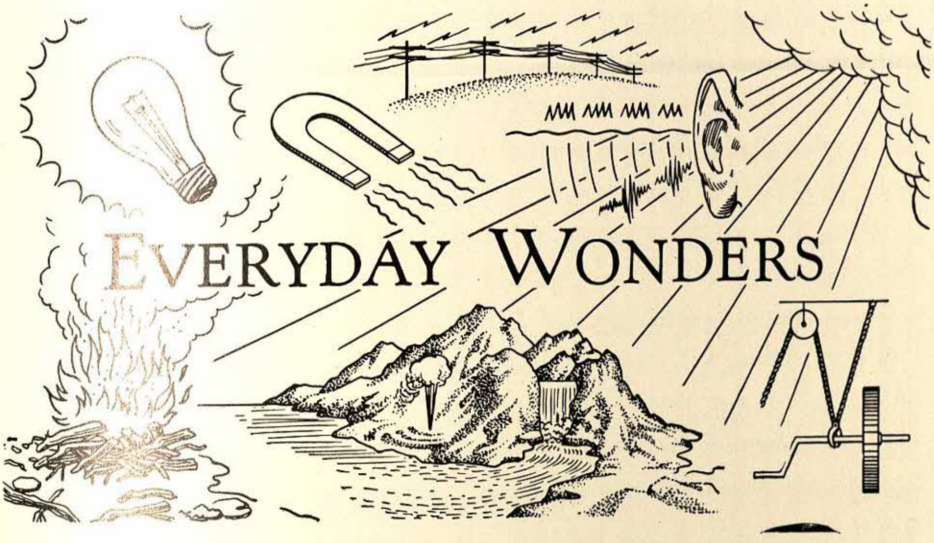
The influence of the weather has been very cleverly expressed in the following verse:

What is it moulds the life of man?
The weather.
What makes some black and others tan?
The weather.
What makes the Zulu live in trees,
The Congo native dress in leaves,
While others go in furs and freeze?
The weather.

Both the very hot and the very cold regions have some desirable things about them and we probably would enjoy visiting them. But most of us, no doubt, prefer to live in a country located between these extreme temperatures where there is some hot weather and some cold, or what we call a temperate climate. The two belts running around the earth midway between the equator and the polar regions have temperate climates.

We in the United States are very fortunate to live in a climate which has the benefits of both heat and cold without so many of the problems of either one. There are changes from season to season so that we can enjoy them all. The weather often changes every few days, which keeps us alert and "on our toes." We have to work for a living, but not too hard. We still have plenty of leisure time. Much of Europe and some of Asia have a climate similar to ours. So do the southern parts of South America, Australia, and South Africa in the southern hemisphere.

Most of the important works of man have been done by people living in the temperate regions. These people have given us just about all of our great music, great books, and great inventions. Climate does have an important effect on people. The dulling sameness and the strain of steady heat or steady cold is not good for the human race. Man is at his best in these "in between" regions of the earth where there are just about all kinds of weather.



EVERYDAY WONDERS

What the World Is Made Of

EVERYTHING in the world is made from one or more elements. The water we drink, the ground we walk on, the air we breathe, and all other substances are made from elements. There are more than 100 elements that occur on earth. Scientists believe that the same kinds of elements are present on the other planets and on the stars.

Oxygen, copper, and mercury are examples of elements. There is nothing in oxygen but oxygen, nothing in copper but copper, nothing in mercury but mercury. This rule is followed by each of the elements. They are the substances that have not been formed from simpler substances. It is these elements that combine in many ways to make the great variety of things that we find all about us.

Names have been given to all of the elements. Scientists do not always use the whole word when they write the name. They use a shorthand way of writing it. They call this the *symbol* for the element. O is for the symbol for oxygen. H is the symbol for hydrogen.

Some of the elements are more common than others. The table on page 112 shows the most important or best known ones. At room temperature some elements are gases, some are liquids, and some are solids. One column of the table contains the letters G for gas, L for liquid, and S for solid.

By studying the chart carefully you discover that just two of these elements are liquids, normally. They are mercury and bromine. Some of the other elements are gases, but most of them are solids. Among the more common gases are argon, chlorine, fluorine, helium, hydrogen, neon, nitrogen, and oxygen.

Most, but not all, of the solid elements are metals. The metals are elements that are lustrous or shiny. All the metals except mercury are solid at ordinary temperatures.

Almost everyone has heard the word *atom*. An atom is simply the very smallest particle of an element that still is like the element. An atom is so small that the very tiniest bit of a substance that can be seen under the most powerful microscope still contains hundreds of atoms.

Atoms themselves are composed of still smaller particles called *protons, neutrons,* and *electrons*. The atoms of every element are made up of these same things—protons, neutrons, and electrons. The electrons have one kind of electrical charge which is called negative electricity. The protons have a positive electrical charge. The neutron is a mass of material the same weight as the proton. It, however, has no electrical charge. It is electrically neutral.

Every atom has most of its weight centered in a spot called its *nucleus,* or center. The protons and neutrons are located in the nucleus and they contribute almost all the weight. Each proton has 1 unit of weight. Each neutron has 1 unit of weight also. The electrons of an atom have practically no weight. The electrons move about in paths outside the nucleus. Sometimes the atom is described as a tiny solar system. The nucleus at the center is in the position of the sun. Around the nucleus, electrons move in much the same way as planets revolve around the sun.

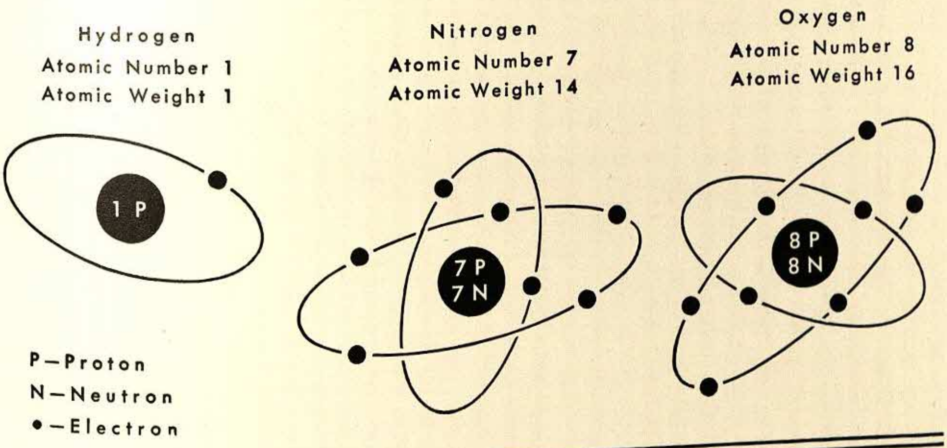
Electrons and protons attract each other. So, as the negative electrons move around in their orbits, they are always attracted toward the center by the positive protons. The attractive force of the electrons and protons for each other helps hold the atom together. But just as a rock whirled at the end of a string keeps going around, the electrons seem to keep going around the nucleus of the atom without being pulled into it by the protons.

Scientists draw pictures of atoms to show how the atoms are probably built. Of course, single atoms have never been seen but their behavior tells us what we know about them.

Every one of the elements has a different number of protons. In the Table of Leading Elements on page 112, the column which gives the *atomic number* tells the number of protons. For each proton in an atom there is an electron. So the atomic number also tells the number of electrons in the atom of an element. Thus the element with atomic number 1 has 1 proton and 1 electron. The element with atomic number 2 has 2 protons and 2 electrons, and so on up to atomic number 92.

This is not the highest atomic number for an element. Californium, an element discovered in 1950, has the atomic number 98 to show that it has 98 protons and 98 electrons. Scientists are continually making new discoveries about elements.

The atoms of different elements have different weights as well as different atomic numbers. The weight assigned an element is called its *atomic weight*. The atomic weight tells the total number of protons and neutrons combined in the nucleus of the atom. The atoms of all elements except hydrogen have neutrons. Since most hydrogen atoms have only 1 proton and no neutrons, hydrogen atoms are the lightest of all. The atomic weight of hydrogen is about 1. Oxygen is about 16 times heavier than hydrogen, so oxygen has the atomic weight 16.



This means that an atom of oxygen has a total of 16 protons and neutrons. It also means that any number of oxygen atoms would be 16 times heavier than an equal number of hydrogen atoms. The atoms of sulphur weigh twice as much as the atoms of oxygen so sulphur has the atomic weight 32. The atomic weights of the elements are in the last column of the table.

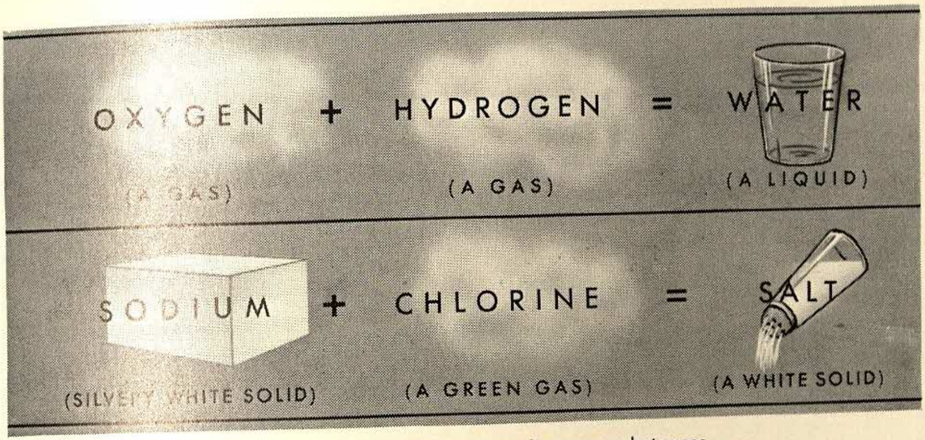
The atoms of elements combine in many different ways to make the great variety of things we have around us. Sometimes 2 atoms of the same element cling together to form larger particles. This is true of some of the gases such as hydrogen and oxygen. For example, 1 atom of hydrogen unites with another atom of hydrogen. This results in a *molecule* of hydrogen. The chemist would write it $H + H = H_2$. More often atoms of an element combine with atoms of one or more other elements to form molecules of different kinds of substances called *compounds*.

For example, hydrogen unites with oxygen to form a substance that is entirely different from either one of them. The compound formed is water. Thus hydrogen (an element) + oxygen (an element) = water (a compound) or $2\ H_2 + O_2 = 2H_2O$. To a chemist this means that 2 molecules of hydrogen unite with 1 molecule of oxygen to make 2 molecules of water. Water is always formed by these two elements combining in this way. The smallest particle of water that still remains water is called a molecule of water. That is, the particle of water (H_2O), made of just 2 atoms of hydrogen and 1 atom of oxygen, is a molecule of water. Each molecule is very, very small so that a single drop of water contains millions of molecules.

H_2O is called the *formula* for water. Chemists usually write the names of compounds by using such formulas. A formula shows how many atoms of each element are in a molecule of the compound.

Compounds usually do not look or act at all like the elements from which they are made. Water is a good example. Water is a liquid. Hydrogen and oxygen which combine to make water are gases. Oxygen helps things to burn, hydrogen burns rapidly, but water neither helps things to burn nor does it burn itself.

Sodium is a silvery white metal. It is a solid but soft and easily cut. Placed on water it reacts violently with the water and gives off a great



How elements combine to make new substances

deal of heat. Chlorine is a green, poisonous gas. When chlorine and sodium unite to make a compound, what do you suppose is formed? Everyday table salt. This is another good example of a compound that is different from the elements of which it is composed.

The following are some compounds whose common names you know.

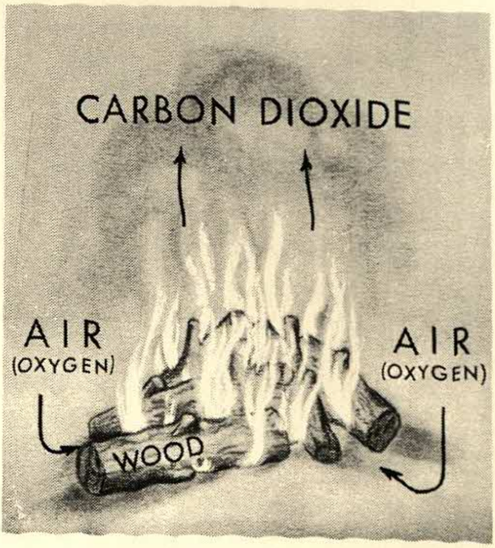
Compound (common name)	Elements in the compound	Formula	Chemical name
Table salt	Sodium, Chlorine	$NaCl$	Sodium chloride
Sugar	Carbon, Hydrogen, Oxygen	$C_6H_{12}O_6$	Glucose
Iron rust	Iron, Oxygen	Fe_2O_3	Iron oxide
Baking soda	Sodium, Hydrogen, Carbon, Oxygen	$NaHCO_3$	Sodium bicarbonate
Limestone	Calcium, Carbon, Oxygen	$CaCO_3$	Calcium carbonate
Hydrochloric acid	Hydrogen, Chloride	HCl	Hydrochloric acid
Lye	Sodium, Oxygen, Hydrogen	$NaOH$	Sodium hydroxide

One group of compounds is called *acids*. Acids are sour. The sour taste of lemon juice, grapefruit juice, and vinegar shows that they are acids. One very important acid, called hydrochloric acid, is formed when hydrogen unites with chlorine. It has the formula HCl.

Another group of compounds is called *bases*. Lye is a good example of a base. Its chemical name is sodium hydroxide and its formula is NaOH. Almost all bases have a metal, like sodium, united with oxygen and hydrogen.

When a compound unites with another compound, two or more new compounds may be formed. For example, when hydrochloric acid is added to sodium hydroxide, two new substances, salt and water, are formed. $HCl + NaOH = NaCl + H_2O$. You see, the elements in the original substances have traded partners. The acid is sour and will seriously burn the skin. The base is bitter and will also burn the skin. But when they are combined they form two entirely different substances. This is just one of thousands of chemical changes that go on in the world about us.

One of the most important of chemical processes goes on in plants. They get carbon dioxide from the air through tiny openings in the leaves, and water comes up from the soil through the roots and stems. By the action of sunlight on the wonderful green substance in plants called *chlorophyll*, the plants are able to use the carbon dioxide and water to make the sugars and starches out of which the plants build their tissues. This process is called *photosynthesis*.



When a substance such as coal or wood is burned, the carbon in it unites with oxygen from the air to form carbon dioxide, and the heat given off is the result of this chemical action. The food we take into our bodies is "burned" in much the same way, combining with the oxygen we breathe to give us warmth and energy.

When baking soda is mixed with an acid such as that in sour milk, a chemical action causes carbon dioxide to be given off. This is why many cooking recipes call for baking soda and sour milk in making cakes or biscuits. The carbon dioxide gas pushes its way up through the cake and causes the cake to rise. An acid is combined with baking soda to form carbon dioxide in one kind of fire extinguisher. Oxygen unites with iron to cause rust. These are all important chemical reactions.

Many of the materials in our world are *mixtures.* Air is one of the most common mixtures. It has several elements and compounds all mixed together. They are oxygen, nitrogen, argon, water vapor, carbon dioxide, and a few other substances. In a mixture the substances are not chemically united with each other. This means they can be present in varying amounts. In air, for example, the amount of oxygen can change. In a compound the amount by weight of each element is always exactly the same. Here is a list of a few mixtures whose names are familiar to you.

Mixture	Substances usually in the mixture
Sea water	Water, salt, iodine, minerals
Milk	Water, butterfat, minerals, protein
Wood	Carbon-hydrogen-oxygen compounds
Gasoline	Carbon-hydrogen compounds
Ink	Water, solid dyes

The elements are all of interest and value but some of them are especially interesting, either because they are so common, or because of their great value to man. A few are interesting because of their unusual behavior.

Carbon (C) is an important and necessary element in all living things. It is also the great fuel. It appears in an almost endless number of compounds. Coal is mostly carbon. In the presence of oxygen and under the influence of heat, carbon burns readily.

Oxygen (O_2) is one of the most common elements, and one of the most useful. It combines readily with nearly every other element, hence besides its abundance in the air, it appears in a great many compounds. It is discussed more fully in the story, "The Ocean We Cannot See" beginning on page 140.

Hydrogen (H_2), the lightest of all the elements, is a gas. Because it is so light it has been used to fill balloons and dirigibles. But hydrogen burns explosively when it is mixed with air and ignited, and several of the world's largest hydrogen-filled dirigibles have exploded and burned.

Helium (H) is also a light gas. It will not burn at all and, therefore, it is much safer for use in dirigibles than hydrogen. Helium occurs in large quantities in some oil fields of the United States but is not plentiful in any other country.

Tungsten (W) is the material used in the filaments of most of our electric light bulbs today. Tungsten makes better filaments than almost any other substance known.

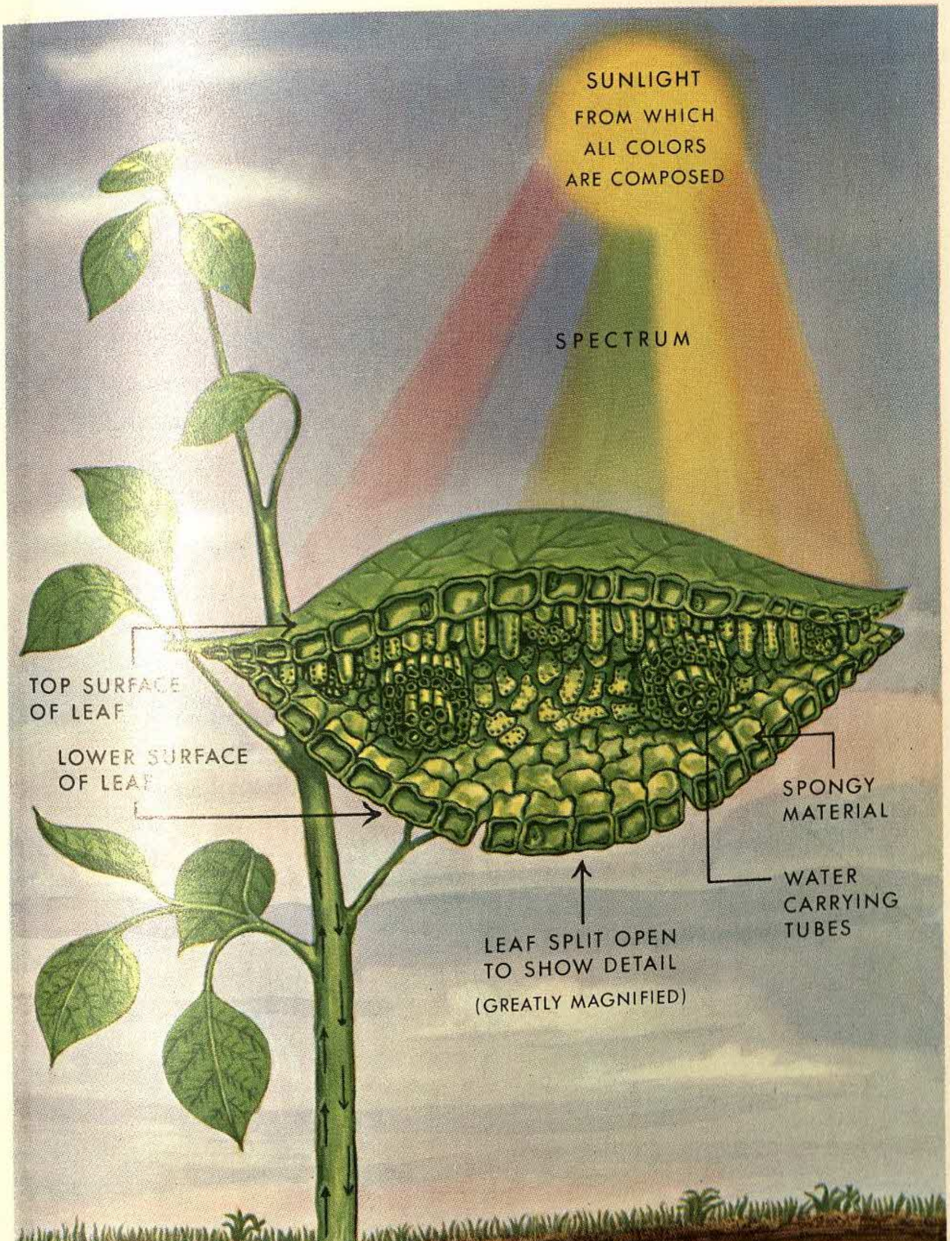
Radium (R) is a metal-like element, quite rare, but of great value. It is used in the treatment of diseases, particularly cancer. Because of the energy which radium atoms give off spontaneously, radium is said to be "radioactive."

Uranium (U) is the heaviest of all elements. It is a metal, and is radioactive like radium. One of its forms, uranium 235, is one of the elements used in making atomic bombs.

With the discovery of atomic energy, man looks forward to many uses that may be made of it. For example, it may be a source of fuel. It has been estimated that the atomic energy in one pound of uranium 235 has as much fuel value as several million pounds of coal. Atomic energy may be used some day in engines to pull our trains and run our machines.

In all of the ordinary chemical reactions such as the burning of fuel and explosions of gunpowder, only the electrons change their position or are rearranged in their orbits outside of the nucleus. But the source of atomic energy is the breaking up of the nucleus within the very center of the atom. It is thought that the heat and light from the sun are a result of the release of atomic energy upon the splitting up of carbon atoms on the sun.

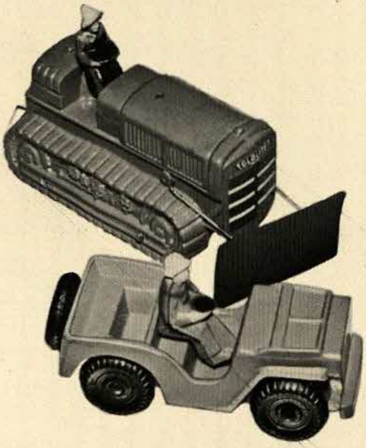
Chemists are people who study about the way materials in our world are made and how these materials behave. In the past, chemists spent most of their time discovering how things were made, what the different substances in the world were composed of.


SUNLIGHT FROM WHICH ALL COLORS ARE COMPOSED
SPECTRUM
TOP SURFACE OF LEAF
LOWER SURFACE OF LEAF
SPONGY MATERIAL
WATER CARRYING TUBES
LEAF SPLIT OPEN TO SHOW DETAIL
(GREATLY MAGNIFIED)
ARROWS GOING UP THE STEM SHOW THE MOVEMENT OF WATER AND SALTS IN SOLUTION
ARROWS GOING DOWN THE STEM SHOW THE MOVEMENT OF FOOD
MAURICE FRIEDLANDER

Nature performs many wonders. None is more wonderful than the process by which a plant manufactures food. Scientists chose a good name for this process when they called it photosynthesis. "Photo" means "light," and "synthesis" means "putting together." That is just what a plant does in making food. It absorbs, through its leaves, the rays of sunlight and sets them to work to combine elements from the air, earth, and water to make food. As you have learned, it is the wonderful green substance called chlorophyll that makes this possible.

No one knows why chlorophyll can do this when other substances cannot. But scientists have learned a great deal about it. This picture shows the way in which the work of making food goes on in the tiny cells of a leaf. It was created to give added and vivid meaning to the description of photosynthesis found on page 106 of this volume.

Chemists test various substances in their laboratories with the hope of finding new synthetic materials



In our modern world, the job of the chemist has changed somewhat. Chemists are now interested in creating new substances. They try to produce in their workshops the same things that occur in nature. In addition, they have produced entirely new materials. They have produced new combinations of elements that do not occur naturally in the world. Such substances are called synthetic products. Artificial rubber, nylon, rayon, plastic, and glass cloth are just a few materials that man has made.

Shown above are toys made of plastic. There are many other uses for this common synthetic material. Plastic can be made into thin, flexible sheets, rigid tubes, soft sponges, solid objects. It can be made into anything from raincoats to weather balloons. Every time you turn on the radio, take a ride in an automobile, or even button your coat you are touching or using something that is made of plastic. Thus we see that man can use chemistry to change and improve our way of living.

TABLE OF LEADING ELEMENTS

Element	Symbol	Form of Matter	Atomic Number	Atomic Weight*
Aluminum	Al	S	13	27
Antimony	Sb	S	51	121
Argon	A	G	18	40
Arsenic	As	S	33	75
Barium	Ba	S	56	137
Bismuth	Bi	S	83	209
Boron	B	S	5	11
Bromine	Br	L	35	80
Cadmium	Cd	S	48	112
Calcium	Ca	S	20	40
Carbon	C	S	6	12
Chlorine	Cl	G	17	35
Chromium	Cr	S	24	52
Cobalt	Co	S	27	59
Copper	Cu	S	29	64
Fluorine	F	G	9	19
Gold	Au	S	79	197
Helium	He	G	2	4
Hydrogen	H	G	1	1
Iodine	I	S	53	127
Iron	Fe	S	26	56
Lead	Pb	S	82	207
Lithium	Li	S	3	7
Magnesium	Mg	S	12	24
Manganese	Mn	S	25	55
Mercury	Hg	L	80	200
Neon	Ne	G	10	20
Nickel	Ni	S	28	59
Nitrogen	N	G	7	14
Oxygen	O	G	8	16
Phosphorus	P	S	15	31
Platinum	Pt	S	78	195
Potassium	K	S	19	39
Radium	Ra	S	88	226
Silicon	Si	S	14	28
Silver	Ag	S	47	108
Sodium	Na	S	11	23
Strontium	Sr	S	38	88
Sulphur	S	S	16	32
Tin	Sn	S	50	119
Tungsten	W	S	74	184
Uranium	U	S	92	238
Zinc	Zn	S	30	65

*Many of the elements have atoms of slightly different weights, and the weights given here are the usual or close to the average for each element. For instance, while most uranium has an atomic weight of 238, it also exists in slightly different forms with weights of 234 and 235.

THE STORY OF HEAT

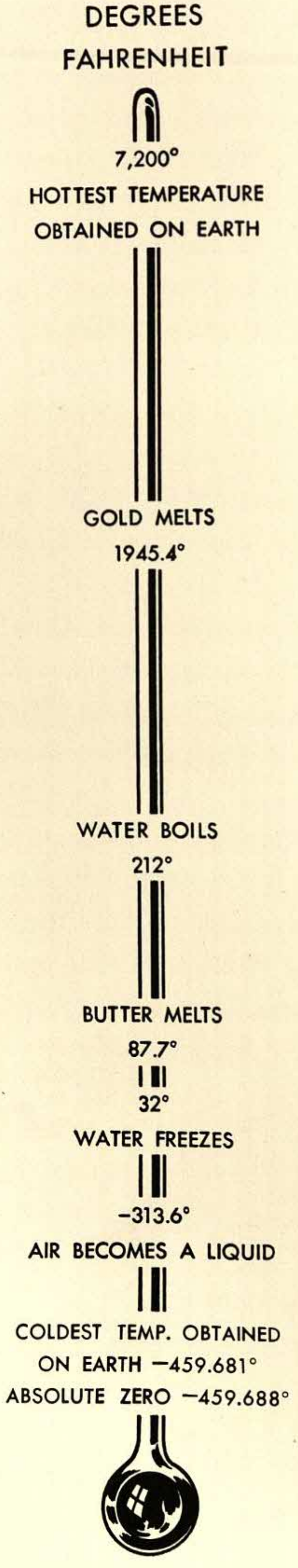
FEW THINGS are so important to us as heat. Heat cooks our food and warms our homes. It does a great deal of work for us, furnishing energy in steam engines to run trains and machines. In fact, a proper amount of heat is necessary to life itself.

People were a long time finding out what heat is. They used to think that it was a mysterious fluid that went in and out of materials. Of course, they could not see it and neither did it seem to have any weight, because an object does not weigh any more when it is hot than it does when it is cold. About 150 years ago, Sir Humphrey Davy proved that ice could be melted simply by rubbing two pieces together, although everything around it was below freezing. Then scientists began to see that heat is not a fluid after all.

We know now that heat is a result of the motion of atoms or molecules, the tiny particles of which every substance is made. These molecules are always moving. In solids they simply vibrate about fixed positions. In liquids the molecules wander about within the entire body of the fluid. They move even more freely in gases, for the molecules of a gas are much farther apart. The speed with which they move depends upon the amount of heat.

As water is heated, its molecules move back and forth faster and faster. When air is heated, its molecules move faster. When the pavement and sidewalks are heated by the sun, their molecules vibrate more violently.

Heated material will cool off when heat is no longer applied to it. This means the motion of its molecules slows down. An object would be the coldest possible if its molecules did not move at all. But scientists tell us that nothing on earth has ever been that cold. Such a point would be reached only at a temperature of about 459° below zero, which is called *absolute zero*.



Therefore, everything has some heat in it. When we say that a substance is cold, it is not true that it contains no heat. It merely means that it is cold compared to something else, perhaps colder than our bodies, so that it feels cold to our sense of touch.

Practically all substances expand when they are heated. As the increased heat causes the molecules to move more rapidly, they bump against one another more often, crowd each other farther apart, and take up more space. On the other hand, these same substances contract again as they are cooled.

It is this expansion and contraction that enables thermometers to measure the degree of heat, that is, the temperature. A common type of thermometer uses a liquid such as mercury. The liquid creeps up in the tube as the heat causes it to expand. Usually the markings tell the degrees on the Fahrenheit scale, named after the German scientist who invented this system. On this scale the freezing point of water is 32° and the boiling point 212°. Another scale used in scientific work and in other countries is called Centigrade. In that, the freezing point is 0° and the boiling point 100°. Sometimes temperatures are given, followed by F or C to indicate which scale is meant; since Fahrenheit is used most often in the United States, all references to temperature in this series of books are to Fahrenheit.

The expansion of materials by heat has been made use of in other instruments, such as the thermostat which regulates temperatures in buildings. But while heat does useful work for us, it also gives us many problems. Telephone and telegraph lines that seem tight in the winter sag in the summer. Pavements sometimes buckle up in bumps during hot summer days. Spaces must be left between the ends of railroad rails so that the rails will have room to expand. Dishes, especially thin water glasses, may crack or break when hot water is poured on them suddenly.

Add or take away enough heat and even greater changes take place. Cool a gas sufficiently and it becomes first a liquid and then at a still lower temperature a solid, just as water vapor when cooled changes first to water and finally to ice. On the other hand, almost all solids, when enough heat is applied, melt, then change to gas.

The temperatures at which different substances change from one state to another varies widely. Water, you know, freezes at 32°. Air becomes a liquid at —313.6°. Gold does not melt until it is heated to 1945.4°, but another metal, mercury, is already a liquid at ordinary temperatures and does not become a solid until it is cooled to —38°.

An object may for some reason have the ability to do work. If so, the object possesses energy. Heat is a form of energy. Other forms of energy are light and electricity; another is chemical energy, that energy which is stored up in such things as food and fuel; still another is mechanical energy, like that of falling water. Heat may be changed into some of these other forms and each of these other forms of energy may be changed into heat.

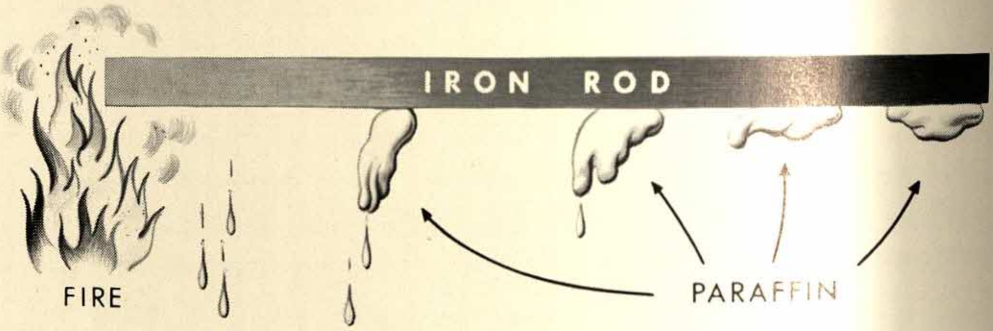
We usually think of getting heat by burning something. The fuel we burn to warm our homes has chemical energy stored in it. Burning releases the chemical energy.

In an electric toaster or electric stove, electrical energy is changed to heat energy. When the sun's rays strike the earth some of the light energy is changed to heat.

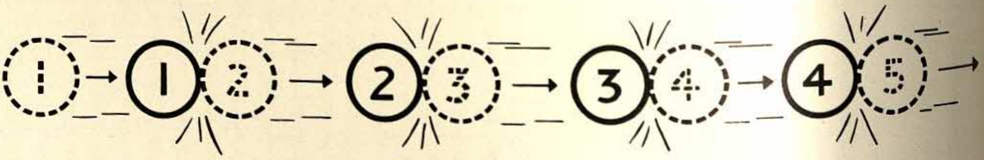
Rub two blocks of wood or any solid objects together and then feel their surfaces. They feel warm to you. These are examples of mechanical energy being changed to heat energy. Whenever machines have parts that rub together, heat is produced. The rubbing is called friction. Heat produced in this way where it is not needed means that energy is being wasted, and oil is used in machines to cut down the amount of friction, thus saving energy as well as wear.

When heat is used to make steam to run an engine, we have an example of heat energy being changed to mechanical energy.

Heat can get from one place to another in different ways. In solids heat travels by *conduction.* If several small pieces of paraffin are attached along an iron rod and one end is held near a fire, the pieces of wax will melt and drop off, one after another. The piece of wax nearest the fire will drop off first, then the next one, and so on until they all drop off. Finally the end of the rod away from the fire will get hot too.



How does the heat travel along the rod? The fire causes the molecules in one end of the rod to move faster. They in turn bump their neighbor molecules. By this increased bumping and speeding up of the motion of adjoining molecules, the heat is carried all along the rod. When the molecules at the far end are moving fast enough, that end also is hot.

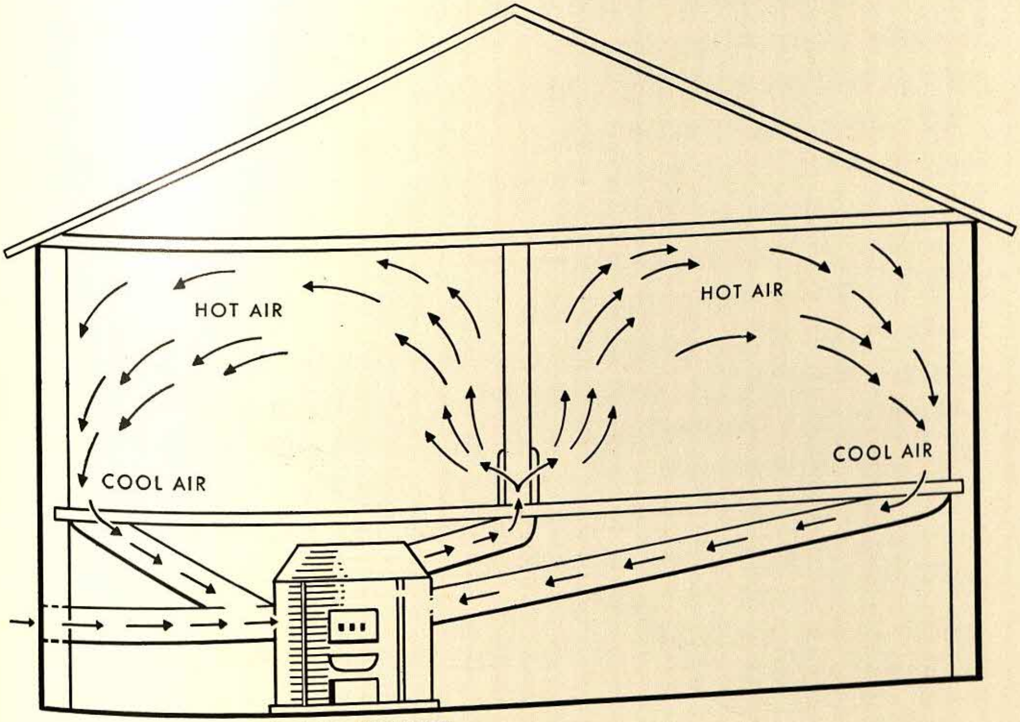


In this way heat travels through solid materials. Cooking utensils usually have wooden handles because wood does not conduct heat nearly as well as metals. Stone and glass are also very poor conductors; so are all gases and all liquids except mercury.

Heat travels through liquids and gases, in addition to conduction, by a different method, called *convection.* All the water in a pan placed on a hot stove will soon get warm. First the molecules near the fire absorb heat energy. They move faster and occupy more space thus becoming lighter. This makes them rise to the top of the pan. The cooler, heavier water then moves down in the pan and is warmed. The movement of the water as the warmer water continues to move to the top and the cool water moves down is called a *convection current.*

Hot water heating systems carry heat from the furnace to the radiators by convection. As the water is heated it rises in the pipes, to be led from the top of the furnace through pipes to metal radiators. From there heat is given out by the hot water to the surrounding air.

Hot air furnaces depend upon convection currents of air. The air gets warmed near the firebox. It then rises up through pipes into the rooms of the house. Cooler air from the rooms returns to the furnace. is heated, and again moves upward. Winds are mostly great convection currents caused by the unequal heating of the surface of the earth and the air above.



HOT AIR FURNACE

You get the warmth from a bonfire mostly by *radiation*

Heat energy travels in another important way known as *radiation*. Our heat from the sun comes to us in this manner. The sun gives off radiant energy. This energy comes through space and when it strikes the earth, some of it changes into heat energy. Radiant energy is not easy to describe because it is much like light energy except that you cannot see it. Radiant energy escapes from all hot objects. It is given off by a fire. You have felt the heat strike your face when you stood in front of a bonfire or fireplace.

Have you ever noticed how warm it is near the sunny side of a building even when it is cold away from the building? Radiant energy changes to heat energy when it is absorbed by something.

In the winter we are interested in keeping warm. We do this in at least two ways. Inside we build fires to heat the air around us, and out-of-doors we depend mostly on additional clothes. Our clothes keep us warm by preventing the heat from leaving our bodies. The heavier or warmer our clothes, the more body heat they trap. Instead of keeping the cold out, our clothes really keep the heat that is radiated from our bodies from getting away.

We are not able to control the amount of heat that comes from the sun, but just as we use fuel and clothing to keep warm when we do not get enough heat, we use devices to take away heat when we get too much. In hot weather, we wear loose, light clothes that allow the heat of our bodies to escape easily. We use refrigerators to cool and thereby preserve our food. Many buildings are air conditioned to keep the air at a comfortable temperature.

Man has accomplished a great deal in controlling heat and making it do useful work for him.

LIGHT AND HOW WE SEE

EVERY morning the sun edges its way up in the east and a new day begins. The sun with its abundant energy lights the daytime world. The rays of the sun are so strong that, even on a cloudy day, there is much light.

Light is a form of energy. That means it can do work. For one thing, it enables us to see.

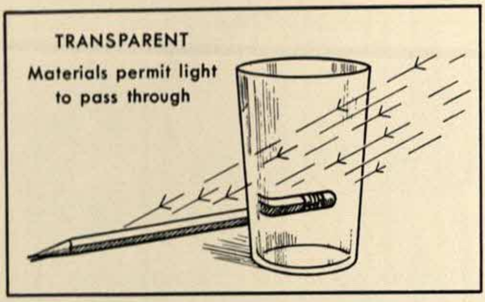
But sunlight does something else which is of the greatest importance to our earth. It enables plants to grow. The leaves absorb some of the sun's energy and use it in making plant food which the plants must have.

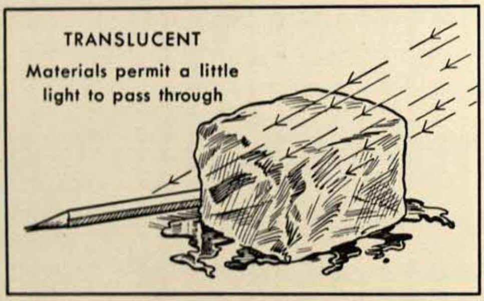
Some objects have a kind of light within themselves, like hot coals and electric light bulbs and fireflies and certain little animals that live in sea water. These things which contain their own light are said to be *luminous.*

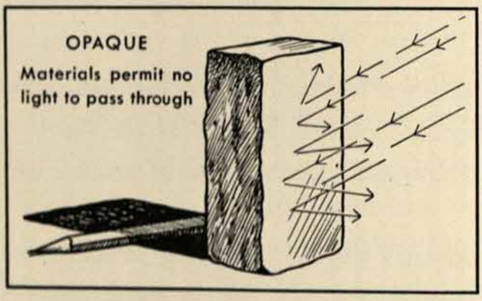
Most objects we can see only because they reflect light to our eyes. You see this book or the house next door or the tree in the yard because of reflected light. These objects, having no light within them, are *non-luminous.*

Light travels more than 186,000 miles in 1 second—faster than anything else in the whole universe. It takes only about 8 minutes for light to reach us from the sun, 93,000,000 miles away. But even at that rate, it takes many years for light to reach us from the stars.

If you look at Arcturus, one of the closest stars, it will twinkle in your eyes tonight with light that left that star 40 years ago. That is, the light of Arcturus traveling at a speed of 186,000 miles a second, takes 40 years to reach the earth. The distance from the earth to a star usually is measured by the length of time it takes the star's light to reach us. Following this method, we say that Arcturus is 40 light years away. Some of the stars that we see are many hundreds of light years away.


TRANSPARENT
Materials permit light to pass through


TRANSLUCENT
Materials permit a little light to pass through


OPAQUE
Materials permit no light to pass through

An unusual ceremony took place at the Chicago World's Fair in 1933. Light from Arcturus, flashing on a little machine, started a signal which officially opened the Fair. This was of particular interest because the light that arrived from Arcturus in 1933, had left the star 40 years before, in 1893, the year that Chicago held its first great fair.

Light travels in straight lines. It cannot curve around buildings or around corners. If it did you would be able to see around objects. You could see objects many miles away, even around the curved surface of the earth. But because light travels in straight lines, it is possible to see only a few miles in any direction. The distance beyond which we cannot see around the earth is called the *horizon*.

The horizon is not a real line. It marks the point where the earth's curve stops light from reaching your eyes from any object beyond that point. The horizon is always as far as you can see.

Light can pass through some materials such as glass and water and cellophane, and these materials are said to be *transparent*. You can see through transparent materials. Then there are materials which permit a little light to pass through them, but not enough to see through them clearly. Frosted glass, ice, and waxed paper are examples. These materials are *translucent*. In early days, the pioneers who seldom had glass, covered their windows with greased paper because it let some light through but kept out the rain and cold.

Solid objects which permit no light at all to pass through them are said to be *opaque*. Such objects cast a shadow when light shines upon one side of them.

The shadows we are accustomed to are not completely dark because light gets into them from other directions by *reflection*. If you stand with your back to bright sunlight you cast a shadow in front of you. If you drop some object like a piece of paper in the middle of your shadow you will be able to see the paper because there is enough light in the shadow to reflect from the paper to you. That light is reflected from dust and moisture particles in the air and from buildings and trees and other objects. So, by reflected light you are able to see things that are not in direct sunlight.

The fact that dust and moisture reflect light is of tremendous importance, because that gives us a more even amount of sunlight. At great heights above the earth, where there is neither dust nor moisture, it is quite dark in directions other than toward the sun because there is nothing to reflect and scatter the light.

If a surface is smooth and opaque, most of the light that strikes it will be reflected evenly. This is true of a mirror, or of a piece of brightly polished metal.

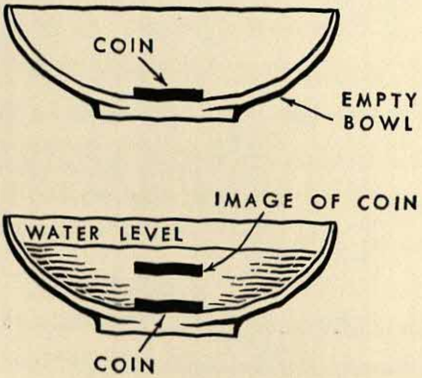
A rough reflecting surface sends the light in many directions, and light scattered by such a surface is *diffused*, like the light from frosted bulbs or windows. Diffused light is more restful for the eyes than direct light.

You see yourself in a mirror because the light is reflected from you to the mirror and back again. We usually use flat mirrors but there are also curved ones. The shiny metal in the back part of an automobile headlight is curved so as to reflect the rays from the light bulb into a small area on the road ahead.

LIGHT RAYS ARE REFLECTED FROM BOY'S FACE TO MIRROR AND BACK
LIGHT RAYS

Some of the large telescopes which scientists use to study the stars have huge reflecting mirrors to help collect light from a star and direct it to the eye of the observer. The largest telescope in the world, located on top of Mount Palomar in California, has a 200-inch glass reflector which enables scientists to study stars thousands of light years away.

Put a knife in a glass of water and notice how the knife seems to be bent. If you move the knife over to the other side of the glass, it will appear to bend in the other direction. Actually, it is the light reflected from the knife which is bent by the water. This bending of light rays is called *refraction.*



Another example of refracted light

Place a coin in a shallow dish and back away until you can no longer see the coin over the edge. Then ask another person to pour water in the dish slowly while you watch. When the water level rises to a certain height, you will suddenly be able to see the coin again. It is not floating, as you know, but the water has bent the light rays and makes the coin appear to be where it is not.

If you see a fish from the edge of a pond, it is not actually where your eyes tell you it is. The fish is below that spot, and the mistake you make is caused by refraction. From where the fish is your head will appear to be some distance up in the air, for refraction will work both ways.

The reflection and refraction of light sometimes plays more serious jokes on people. Desert travelers have often been confused by seeing what looks like an oasis a short distance away only to have it disappear when they approach it. What happens is that certain conditions of the atmosphere cause refraction so that an object seems relatively close when it really is far away below the horizon. Such a vision is called a *mirage.*

There is no lake in the distance. It is a mirage. The scene below shows the land as it actually appears.

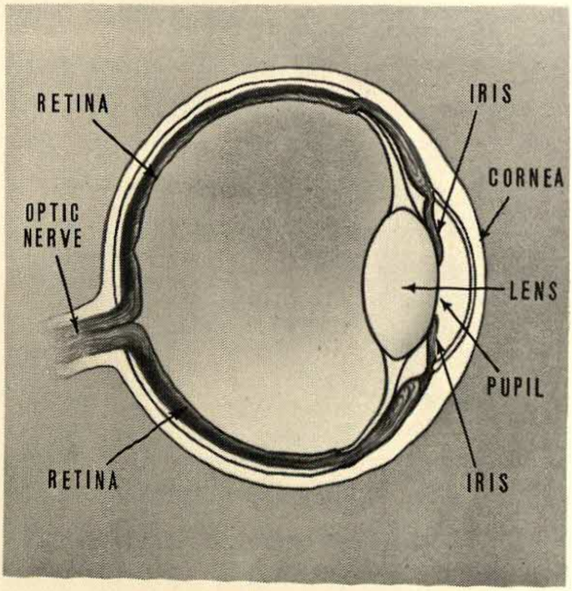
White light is really a mixture of several colors of light. Often when bright sunlight passes through an aquarium or glass bowl filled with water, it forms a rainbow on the floor or nearby wall. This has the same pattern of color as a rainbow in the sky caused by the sun shining through a shower of rain. The colors are violet, indigo, blue, green, yellow, orange, and red—always arranged in that order. The rays of sunlight are being bent, and some light bends more than other light. The violet part bends the most, the red the least, and the others are in between.

Objects appear to us the same color as the color of the light they reflect. A red apple reflects red light and absorbs the other colors. A yellow pencil reflects yellow light and absorbs the other colors. A white object reflects all colors of light equally and a black object does not reflect any light. Thus, black is the absence of light.

White cellophane permits all the colors of light to pass through it. Colored cellophane permits only the light of that particular color to pass through. Blue cellophane, for example, permits only the blue part of the white light to pass and blocks out the other colors. The colors that we see are always the colors that come to our eyes from the objects we are looking at.

Pieces of curved glass called *lenses* bend light. Because of this they have many important uses. The most common use is in eye glasses, but lenses are also used in microscopes and telescopes.

There are two kinds of lenses, concave which curve inward, and convex which curve outward. Eye glasses are either concave or convex, depending on the need of the person who wears them. Concave lenses spread the light out over a wider area, and convex lenses gather the light toward a point, called a *focus.* If sunlight is focused through a large convex lens, enough heat can be directed to one spot to start a fire in paper or wood shavings.

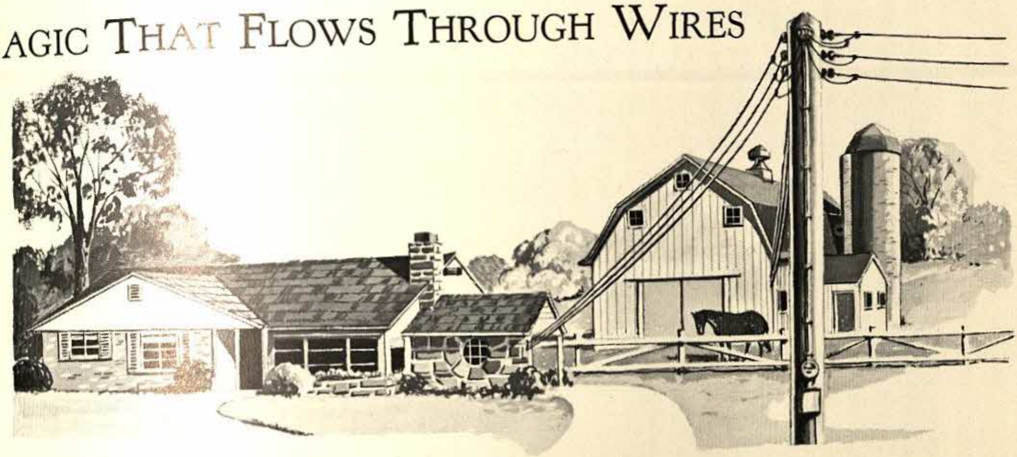


The most wonderful lenses are those in our own eyes. These are not made of glass, of course, but they work the same way, and bend light as a glass lens bends light. Light comes in through the *cornea,* a thin membrane which covers the outside of the eye. Then it passes through a small opening, called the *pupil.* The lens, directly behind the pupil, bends the light so that it strikes the *retina.* The retina is a tiny screen with nerves running to it which carry an impression of what is being seen directly to the brain.

If more light is needed on the retina in order to see well, the pupil opens wider. The size of the pupil is regulated by the *iris,* a membrane surrounding the pupil, which gives eyes their color. The eyeball is filled with a liquid which helps the eye keep its shape and helps the lens to bend the light rays and focus them on the retina.

When we look at distant objects, the lenses of our eyes become thinner. When we look at close objects, the lenses get thicker. The change is regulated by small muscles that work without our thinking about them. Sometimes, however, the lenses do not change shape easily or the shape of the eyeball is such that images do not form properly on the retina. The lenses need help. It is then that people wear glasses. The glasses help direct the light so that it forms clear images on the retina.

MAGIC THAT FLOWS THROUGH WIRES



PRETEND that your family has just purchased a farm or new country home. It is equipped with all of the conveniences of modern living—except that there is no electricity! Imagine what fun it would be to watch your house being wired for electricity for the first time. First, workmen would sink a huge pole into the ground and attach long wires to it. This is called the power line. Then connecting wires are run from the line to the house.

Inside you would see strange things happening—holes being bored in walls and floors, and wires enclosed in wrappings being run all through the house. The ends of the wires in every room are fastened to the sockets into which electric cords are plugged.

Now the electricity can be turned on. Someone pushes a switch in the living room and the room is suddenly bright with light!

Something certainly came into the house through the wires. But how? What was it? We know about some of the many kinds of useful work electricity can do for us, but it is a little harder to understand just what electricity *is*. Of course, it is a form of energy. It may be changed into other forms of energy like heat and light and mechanical energy, and these other forms may in turn be changed into electrical energy.

Scientists think that an electric current is a flow of electrons through a conductor. Electrons, you remember from the story "What the World Is Made Of" beginning on page 101, are the tiny particles of matter found in the atoms of all elements. The electrons move about in a particular atom, and some of them can easily be made to move about in a piece of material, in which case the material is called a conductor. The conductor may be a copper wire, or a strip of zinc metal, or perhaps a liquid.

There are two common ways of producing an electric current: chemically in batteries, and mechanically by generators.

First let us see how batteries work. The electric current that lights a common flashlight bulb comes from a battery called a dry cell. The cell is not really dry. There is a wet paste in it. The dry cell is a store of chemical energy. When the chemicals act on each other, they free electrons which flow through a conductor, thereby producing an electric current. Most dry cells are made with a carbon stick surrounded by a paste of chemicals, including ammonium chloride, and placed inside a zinc metal container which, in turn, is enclosed in cardboard.

No electric current is produced unless the electrons are given a chance to move through a conductor from the zinc metal and back to the carbon stick. The chemical action of the paste on the carbon stick and the zinc container causes electrons to move away from the carbon and to the zinc.

You will remember, too, that electrons are tiny charges of negative electricity. The place where they collect, which in this case is the zinc metal, is called the *negative electrode*. After they flow through the conductor and return to the battery, they come to the *positive electrode,* which in the dry cell is the carbon stick. These electrodes are often marked — and +. Keep in mind that the negative electrode (—) gives off electrons and the positive electrode (+) gets them back, that is, the electrons flow from the negative toward the positive.

The path provided by the conductor between the electrodes is called a *circuit*. The object of a switch is to *close* the circuit permitting the current to flow when it is wanted and to *open* or break the circuit by causing a gap in the conductor when the current is not needed. Dry cells are very convenient for supplying small amounts of electricity, such as that used to light a flashlight, to ring door bells, and to do many other small jobs. If more power is needed than one cell will provide, two or more cells may be connected.

MAURICE FRIEDLANDER

* * *

At Niagara Falls, and other places where there are big waterfalls, the force of the falling water is used to make electricity. In many sections of the country where there are no waterfalls, streams and rivers have been dammed to force the water to fall from a great height.

Power plants at these dams change water power into electricity. The electricity generated in these huge hydro-electric plants is then sent over wires, often for hundreds of miles, to do all kinds of work. The Hoover Dam on the Colorado River sends power to the city of Los Angeles in California.

Great dams like the Hoover Dam and the Bonneville Dam on the Columbia River have been constructed to serve more than one purpose. They have been built to control floods, to regulate irrigation, as well as to supply water and electric power for cities and farms.

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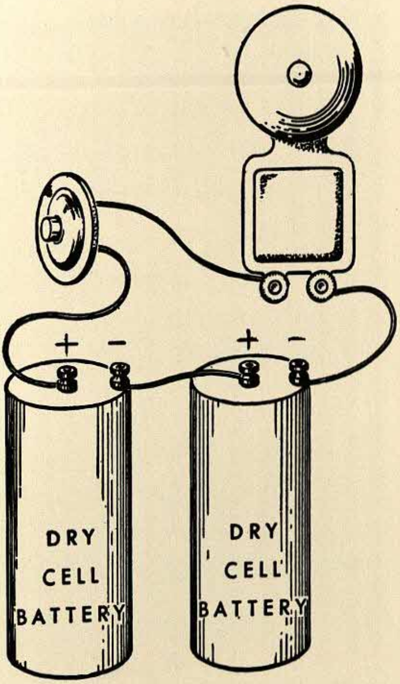
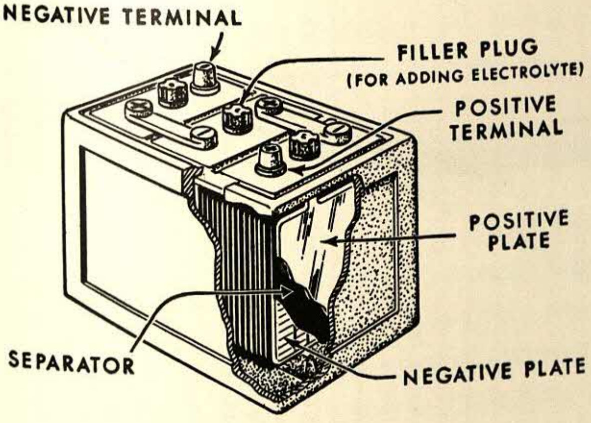


Let us see how two dry cells would be wired to an electric bell to ring it. A wire runs from the negative electrode of the first battery to the positive electrode of the second one. From the negative electrode of the second battery a wire goes to a switch. From the other side of the switch the wire goes to one binding post of the bell. From the other post of the bell a wire runs back to the positive electrode of the first battery. When the switch is closed, usually by pushing a button, it makes a closed circuit. The electrons cause the bell to ring as they hurry through the circuit.

Storage batteries such as those used in automobiles are wet batteries. They are made of cells having a liquid in them which acts on metals to free the electrons, just as the ammonium chloride paste does in the dry cell.

The liquid is a solution of sulphuric acid. It acts chemically on two sets of metal plates. One set is made of lead, the other of lead peroxide. When the circuit is closed, electrons are freed at the lead plate, making it negative. These electrons then flow out through the circuit and do their work as they move back to the positive plate of the battery.



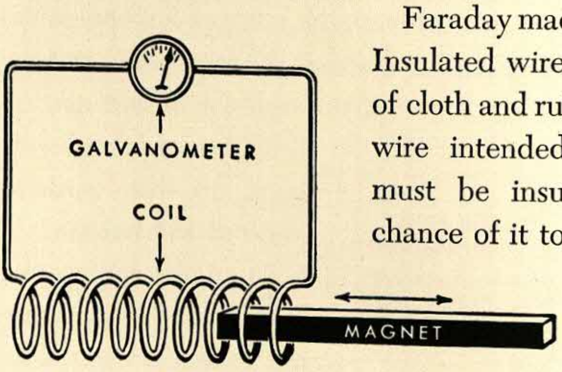
In an automobile the electrical energy from the storage battery does several different jobs. It operates the starter, the horn, and the lights.

It supplies a spark in the spark plugs to explode the gasoline which causes the engine to run. Such batteries are used to do these larger tasks because they furnish more current than dry cells do. But there is a more important way in which these two types of batteries are different.

In a dry cell the source of the energy exists in the chemicals, and when they lose their energy, the battery is worn out. While a wet storage battery must first be "charged" with energy before it will operate at all, the energy can be replaced as it is used. Thus, by keeping it charged, it will go on storing and releasing energy. The charging is done by running an electric current into the battery from a generator. The charging process stores up chemical energy in the solution and on the plates to be released as electrical energy when the circuit is closed.

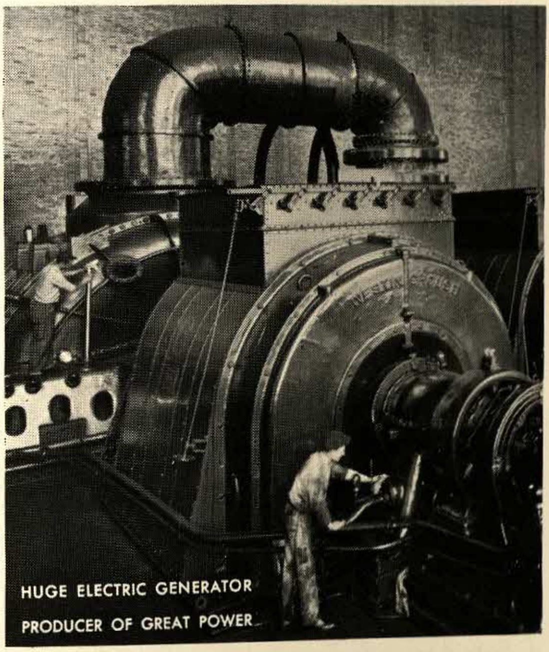
Most of the electricity we use in our homes and in industry comes directly from electric generators. If we followed the electric wires from our house to their very beginning, we would arrive at a power plant. In the power plant we would find huge generators being turned by engines or by water power.

There was a time just over a hundred years ago when we did not know how to produce electric current by means of generators. Then one day an Englishman by the name of Michael Faraday discovered he could cause electrons to move through a wire without using chemicals.



Faraday made a coil from *insulated* wire. Insulated wire is wire with material made of cloth and rubber wrapped around it. All wire intended to carry electric current must be insulated where there is any chance of it touching any other conductor which would cause a "short" or sidetracking of the current. Faraday fastened the ends of wire together as shown in the picture. This made a complete circuit. He then produced a current of electricity simply by moving a magnet through the coil. He had caused electrons to move along the wire.

Faraday made another important discovery. When one end of a



HUGE ELECTRIC GENERATOR
PRODUCER OF GREAT POWER

magnet was thrust into the coil, the electrons moved in one direction. When the magnet was pulled out, the electrons moved in the other direction. This back and forth motion of the electrons is called *alternating current.*

Other scientists quickly made use of Faraday's discovery to produce huge generators by which large amounts of electric current could be made. But no matter how big they are, or how complicated they look, modern generators all work in much the same way as Michael Faraday's little combination of wire coil and magnet.

To turn a generator requires power. In many communities, the power plants are run by engines which burn fuel, but where water power is available, it is much cheaper to let the falling weight of the water do the work. Thus our largest and cheapest sources of electric power are at dams and waterfalls. Huge hydroelectric plants such as those at Grand Coulee Dam on the Columbia River, Hoover Dam on the Colorado River, and Niagara Falls, each furnishes enough power to supply factories, cities, and farms over wide areas around them.

Water from above the dam or falls runs off into huge tubes called penstocks which lead to turbines below. A turbine is a large spiral fanlike blade that turns when the water runs onto it. The turbine then turns a generator.

In most large generators, huge magnets on a shaft revolve within the coil of wire, or *armature,* which remains stationary and is connected to the power line directly. However, in many generators the magnetic field is stationary and the armature revolves. Then to make a circuit with the power line, brushes are attached to the ends of the coil to make contact with a conductor as the armature turns, or revolves.

So we find that electricity, like many other things can be produced in very large amounts or very small; that there are large currents and small currents. Let us see how an electric current is measured.

The rate of flow is measured in *amperes*. The more electrons moving along a wire, the greater the number of amperes.

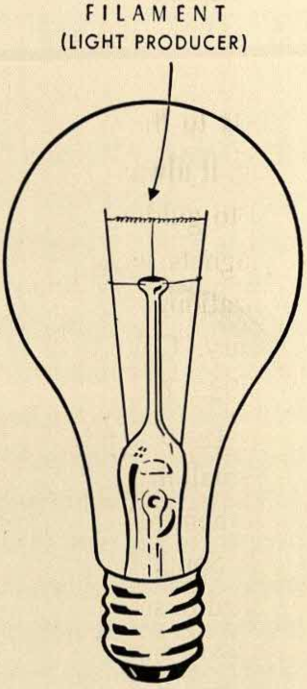
Everything takes some push to move it. This is true of electrons. The push or force that does this is measured in *volts*. The more volts, the more push. A battery of 22 volts, for example, will push more amperes of current through a certain closed circuit than a 6 volt battery will in the same length of time.

Some conductors let electricity pass through them easily. Copper wire is one of the best and most commonly used conductors. Electricity passes through other materials only with great difficulty. Such substances have a big resistance. The amount of resistance of a conductor is measured in *ohms*. A wire 10 feet long has twice as much resistance as a piece of the same wire 5 feet long. The greater the resistance, the more volts are required to carry the same number of amperes. Scientists have determined exact standards for measuring these quantities and a volt of electricity is the amount of push required to put one ampere of current through a resistance of one ohm.

Dry cell batteries usually have about 1½ volts. The average battery of an automobile has about 6 volts, which is composed of 3 cells of 2 volts each. Of course this is very little as compared with the many thousands of volts developed by each generator found in a huge hydroelectric plant.

Watt is another term used in measuring electricity which refers to the amount of work done every second by a current of one ampere under a pressure of one volt. Most light bulbs are marked in watts. A 60 watt bulb burning for 1 hour uses 60 watt hours of electric energy. However, since a watt is a very small unit, a *kilowatt* which is 1,000 watts, is generally used in speaking of larger quantities of electric power. The electric meter in your home measures the amount of electric energy you use in *kilowatt* hours.

We have come to depend a great deal upon electricity in our everyday living. Perhaps first of all comes electric lights. The resistance of the filaments in the light bulbs as the electrons pass through them causes the filaments to glow and produce light. This glowing is called *incandescence.* Thomas Edison invented the incandescent light after searching for years to find a satisfactory material for the filament. He also invented or improved many other electrical devices.



In electric irons, toasters, and stoves, the electrons cause the wire through which they pass to become very hot. These devices use much more electricity than do ordinary electric lights.

The electric motor is an important part of many household appliances. It runs the washing machine, the vacuum sweeper, the electric fan, the electric refrigerator, and dozens of other machines. It also runs the dentist's drill. In industry electric motors have a wide variety of uses.

A motor is the opposite of a generator. Instead of producing electricity, the motor uses it to make the armature revolve and do work. The motor changes electrical energy into mechanical energy.

But important as electricity is in our daily lives in producing heat, light, and power, these are by no means all of its valuable uses. It is used in putting a thin coat of one metal such as silver or copper over another metal, which is called electroplating. Some kinds of silverware are made of brass with a silver coating. The bumpers and door handles on your car are probably chromium plated.

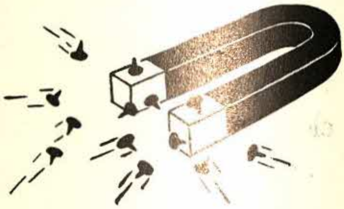
Electricity is used in producing the X-ray and is valuable to the physician in many other ways. It carries messages for us over telegraph wires, and enables us to talk over the telephone. It makes possible the broadcasting and receiving of radio and television programs. In fact, it would take several pages just to list the more common uses of electricity.

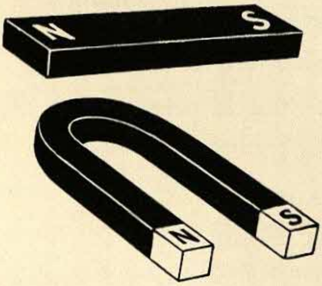
MAGNETISM

LONG ago a kind of black iron ore that was quite unusual was discovered in the earth's surface. It would attract iron objects to it. When a long, slender piece of the ore was hung by a string, it always came to rest in a north-south position. The stone was used to guide travelers and so was named leading-stone or lodestone.

Magnets were known to the Chinese very early in the history of civilization, and the compass was in use in Europe before the 15th Century. Columbus used a compass on his voyage across the Atlantic in 1492. Today we are not dependent on pieces of lodestone—our magnets are man-made. They are doing many important tasks.

A small magnet may be purchased for a few cents and many children have them for play-things. Such magnets are made of a bar of iron or steel. Some are horseshoe or U-shaped. If one end of the magnet is touched to small objects made of iron such as tacks or small nails, the magnet will pick them up. Other substances like copper, gold, paper, rubber, or wood will not be affected by it. Iron, cobalt, and nickel are the only substances that are highly magnetic.

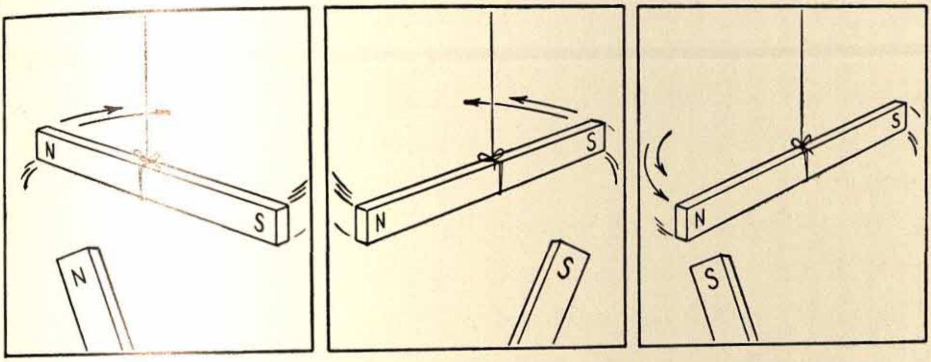




There are some substances, mainly antimony and bismuth, which are weakly repelled or pushed away by a magnet.

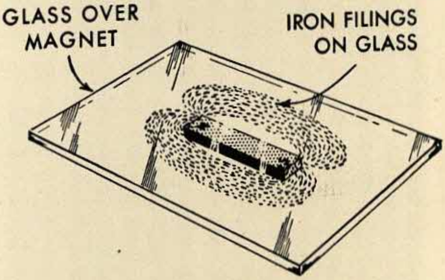
Every magnet has two poles. One end is called a north pole and the other a south pole. Sometimes the poles of magnets are marked N and S. Both poles will attract iron. Yet they are different, as a simple experiment will show.

Tie a string around the center of a bar magnet so that the magnet will hang level. Then let the magnet swing freely. Hold the N pole of a second bar magnet near the N pole of the first magnet. You will see the N pole of the suspended magnet pushed away by the N pole of the other magnet. Now hold the S pole of the second magnet near the S pole of the first. They, too, repel each other. Hold the S pole near the N pole. These poles are attracted to each other. So you see there

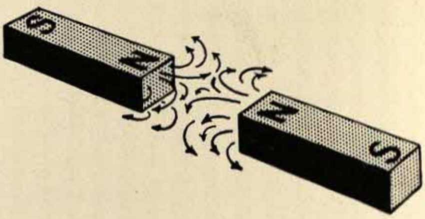


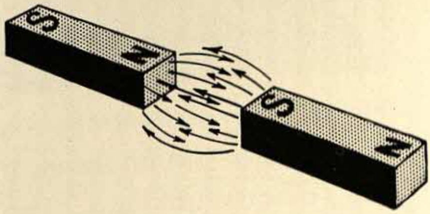
is something different about the N and S poles of magnets. The north and south poles attract each other, although the north repels the north, and the south repels the south. This is always true of all magnets.

The space around a magnet in which a piece of iron is affected by it is called the *magnetic field.* Even though the mysterious force cannot be seen, it is possible to get a picture of the magnetic field. If a piece of glass or paper is placed over a magnet and iron filings are sprinkled upon it, the filings will arrange themselves in curved lines that seem to come out of the north pole and pass in a curve around to the south pole. These lines are called *lines of force.*



If two north poles or two south poles are placed near each other, their lines of force seem to push against each other and crowd apart. This suggests why like poles repel each other. If a N pole is placed near a S pole, the lines of force run from the N pole directly to the S pole. The arrangement of the iron filings suggest that the lines of force are pulling the opposite poles together.





Every piece of magnetized iron

has a north and a south pole. If this iron is cut in two pieces each piece is a magnet with a north and south pole. These pieces in turn may be cut in halves and they, too, would have north and south poles. This fact gives us a clue to the condition of a piece of iron when it is magnetized.

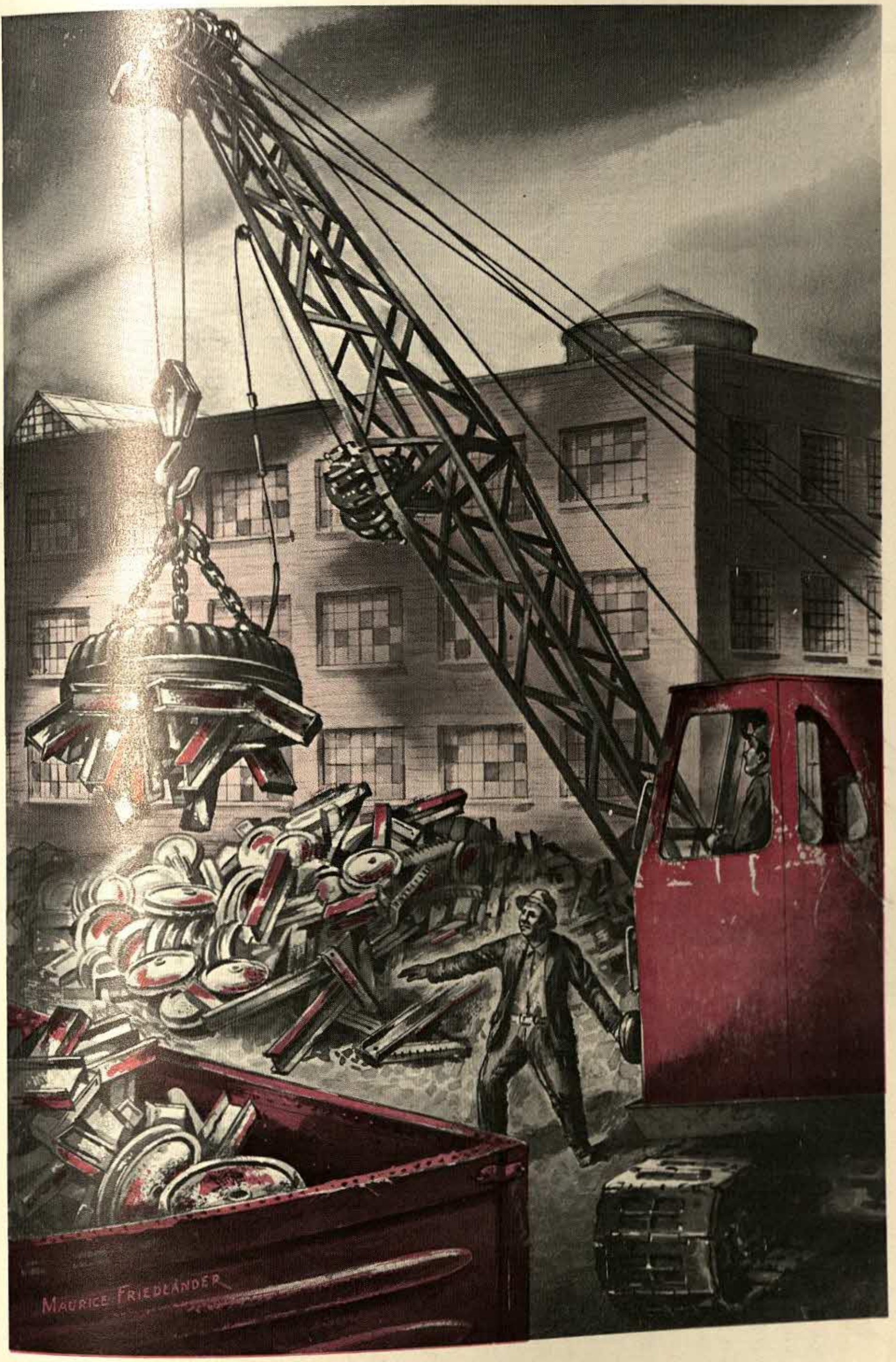
You remember that all materials in the earth are made up of small particles called molecules. Iron is made of molecules. Probably each little molecule of iron is a magnet. When the molecules of a piece of iron are mixed, with their poles pointing in every possible direction, then the iron is not magnetized. But when the molecules get lined up so that many of their south poles point in one direction and the north poles in the other, then the iron is magnetized.

There are several ways to magnetize a piece of unmagnetized iron. Each method arranges the tiny molecules so that their N and S poles point in opposite directions. Here is an easy way to magnetize an ordinary nail. Hold it in one hand with the point out. Then stroke the nail with the N pole of a magnet. Stroke toward the point of the nail and stroke it several times. Then the nail itself will be a magnet and it will attract other pieces of iron.

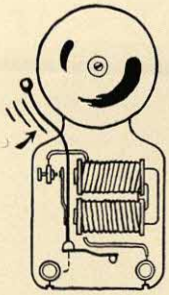
Iron will keep its magnetism for quite a long time, but will lose it more quickly than a piece of hard steel. For this reason, most bar and horseshoe magnets are made from steel. Because such magnets keep their magnetism so long, they are often referred to as permanent magnets. Magnets of soft iron which can be magnetized easily but which lose their magnetism easily are called temporary magnets.

The most useful kind of temporary magnet is the *electromagnet.* It is made by passing an electric current through a covered wire that has been coiled around a soft iron bar. The strength of an electromagnet can be increased by wrapping more turns of wire around the iron, or by increasing the amount of current passing through the coiled wire.

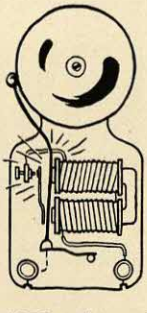
One of the most important advantages of the electromagnet is that it has its magnetism only while the electric current is turned on. Electromagnets are a necessary part of many electrical devices. They are the heart of telegraph sounders, electric doorbells, and the huge electromagnet lifting cranes that are used to load and unload scrap iron or heavy iron bars. The crane, having picked up its load with



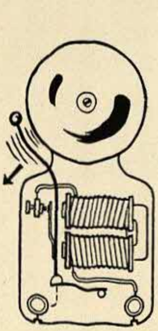
the current on, is swung to the position where the iron is wanted. Then as the current is turned off, the load is released.



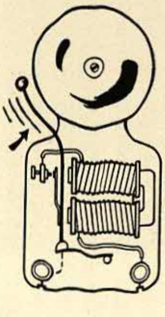
MAGNET pulls CLAPPER ARM



CLAPPER striking BELL
breaks current



CLAPPER ARM springs back

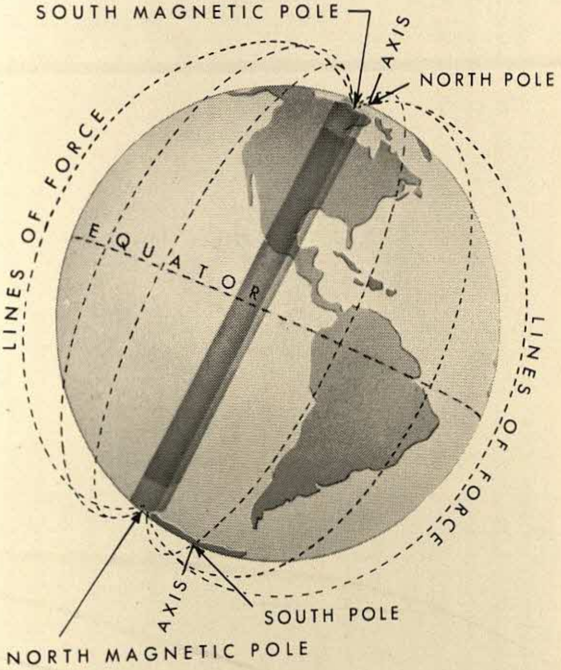


Flow of electricity
again pulls ARM back

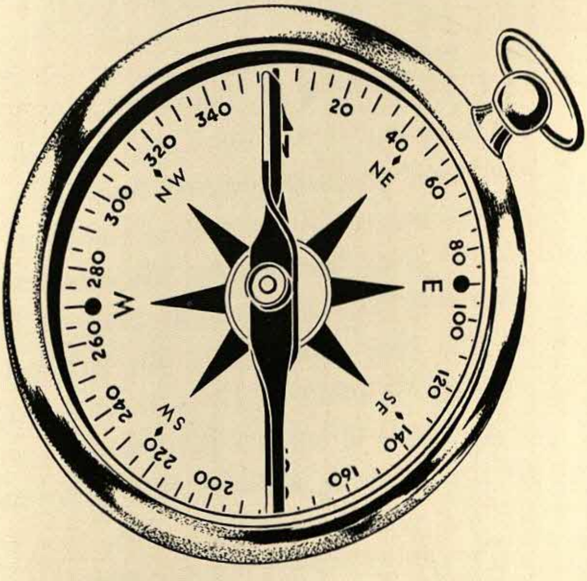
Let us see how an ordinary electric bell operates. When the button is pushed to close the circuit, electricity flows through the coils of wire in the electromagnet. The magnet pulls the arm to which the clapper is attached, making the clapper strike the bell. As it does so, the path of the electric current is broken so that the magnet loses its strength, and the spring in the arm causes the arm to snap back. But when it snaps back, the path of the electric current is closed again and the magnet, regaining its force, pulls the clapper arm toward it once more, again causing it to strike the bell. Of course, this action takes place very rapidly, giving the bell almost a steady ring. It will continue as long as the button is pushed in.

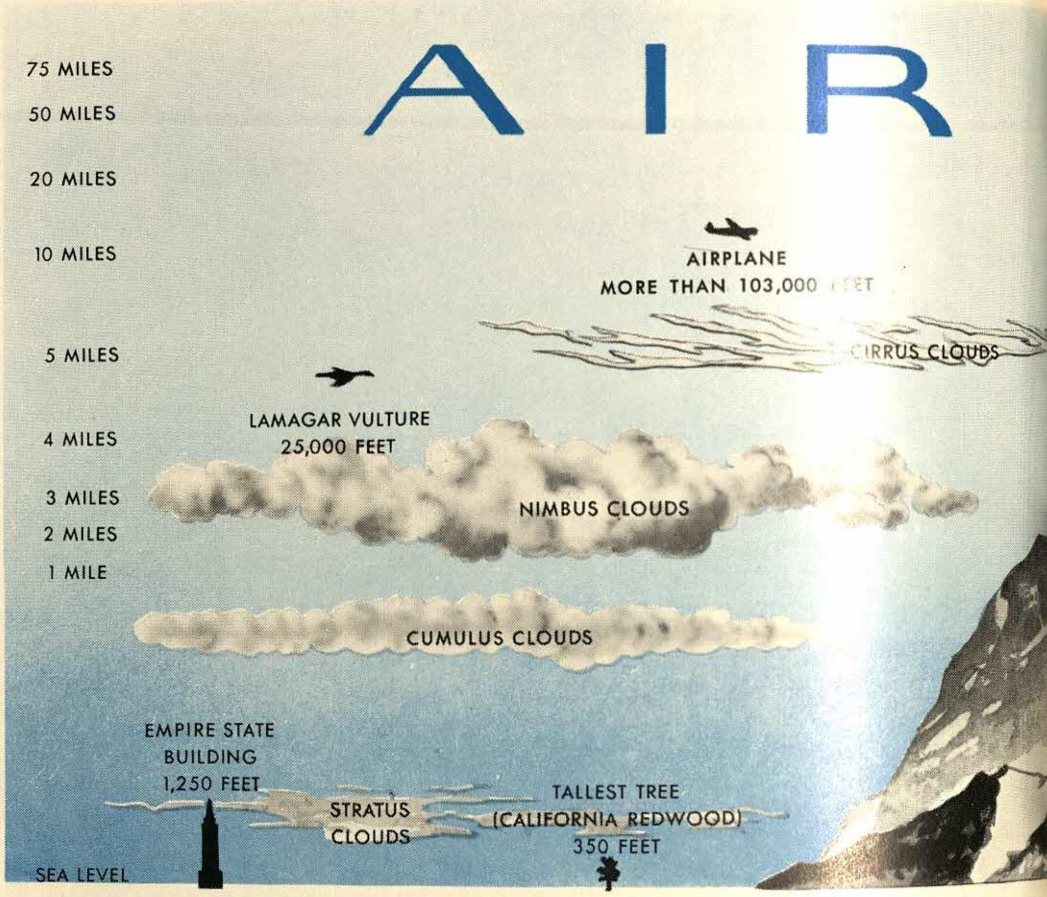
Magnets are a necessary part of every electric motor and electric generator. They are used in telephone receivers, in radio loudspeakers and in many other devices. The use of a small bar magnet by doctors to remove particles of iron or steel dust from the eye is interesting. In beauty parlors, a magnet is used to take out hairpins from a woman's hair after the hair has dried, saving much time for the hair dresser.

The earth itself is a huge magnet. One magnetic pole is in Northern Canada about 1,000 miles from the North Pole. The earth's other magnetic pole is near the South Pole. It happens that the magnetic pole in the north is a south magnetic pole. And the pole in the south is a north magnetic pole. When a bar magnet is allowed to swing freely, the end marked N will point to the north. We have learned that unlike poles attract. So it must be a S pole in the north that attracts the N pole of the magnet.



A compass needle is a small magnet balanced so that it will turn freely. The N pole on the compass points toward the magnetic pole in the north. Since the northern magnetic pole is not exactly at the North Pole the compass needle in most parts of the earth does not point true north. The compass is a useful direction finder, however, even though it is not perfectly accurate. A compass should not be used near large iron objects, as they will influence the compass needle and may make it point in the wrong direction. In using the compass you must permit the needle to come to rest. Then you turn the base of the compass until the letter N on the face of the compass is at the pointer of the needle. The other letters on the compass then correctly indicate South, East, and West.



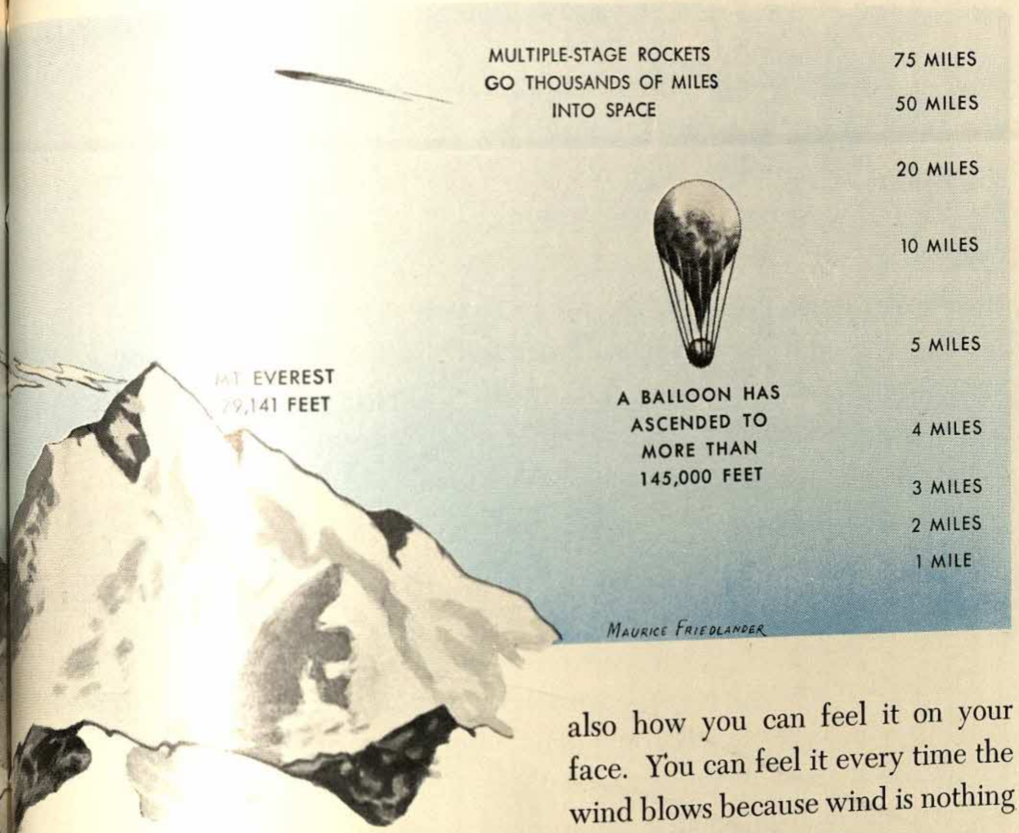


THE OCEAN WE CANNOT SEE

WE LIVE on the bottom of a tremendous ocean, an ocean so big that it covers the whole world, yet we cannot see it. It is not made of water, like the Atlantic and the Pacific and the other oceans; it is made of gas, the gas we call air.

Air is everywhere on the surface of earth, and it is wrapped around the earth like a blanket many miles thick. There is air in your yard, in your room, and even inside you, because you are breathing it in and out all the time. Every tiny bit of space that is not full of something else is full of air. It is the most common thing in the world, yet one of the most valuable. Neither animals nor plants could live without it.

We cannot see air, but we can feel it. Wave your hand rapidly past your face. Note how you can feel the air passing your fingers and



also how you can feel it on your face. You can feel it every time the wind blows because wind is nothing more than air in motion.

Have you ever watched a leaf floating to the ground? It falls slowly because it is so light that the air under it holds it back. If there were no air, a leaf and a rock would both fall at the same speed. The next time you are outside, open your coat and hold it wide. Then try to run. The reason that you cannot run as fast as usual is because your coat catches so much air.

The same idea saves the lives of men who jump from airplanes. The big, billowing parachutes, donned for jumping, catch the air and thus keep the parachuters from falling too fast to make a safe landing. On the other hand, in order to lessen the resistance of the air, as they push through it, and thereby increase their speeds, airplanes, automobiles, and trains now have streamlined shapes.

A light wind enables a kite to fly because the push of the air is then strong enough to hold up the kite. An airplane flies because its propellers force the plane ahead as they cut their way through the air, and at the same time the speed of the plane holds it up by a lifting effect due to the air rushing past the wings. Yes, air is a very real substance even though we cannot see it.

Air is a mixture of several gases, but most of it is oxygen and nitrogen. Oxygen is the part used in breathing and in burning. One of the ways that nitrogen helps us is in diluting the oxygen, as pure oxygen is too strong for most purposes. Air is about 21 per cent oxygen, 78 per cent nitrogen, and only one per cent other gases, chiefly argon, carbon dioxide, and water vapor.

We breathe out carbon dioxide from our lungs. Carbon dioxide is formed whenever something is burned. Therefore the air in cities, where many people live close together, does not have quite the same composition as air in the country. With all the breathing and all the fires in a city, you may wonder why the air does not become more and more filled with carbon dioxide. The reason this does not occur is because the leaves of plants take it in, remove the carbon for their use and give most of the oxygen back into the air.

The farther above the earth we go, the thinner the air gets. There is much less air on a high mountain than there is at the seashore. People carry tanks of oxygen with them to help them breathe when they fly higher than about 3 miles. There is a very small amount of air at a height of 100 miles or even higher but almost all of the air is below 15 miles, and half of it is below 3½ miles.

Probably you have noticed that bubbles come to the top of a pan of water when it is being heated. Tiny bubbles also collect on the side of a glass of water that is left in the warm sunlight. So there is air in water too.

Once some children thought that they would make the water for their goldfish pure by boiling it. So they boiled the water and then cooled it. The goldfish died very soon after they were placed in it. Heating the water had driven out almost all of the air. Of course, if the water had been left to stand again for a few days, it would have absorbed some more air. Running water or water that is being churned around takes up all the air that it can hold quite rapidly. Plants growing in the water help put oxygen into the water.

There is also air mixed in the soil. Worms and other animals that live in the soil need air to breathe. You can see air bubbles come to the top when you pour water into a jar of dirt. The water forces the air out from between the particles of dirt.

When you blow into a rubber balloon you crowd air into it and make it stretch. You are pushing the tiny little particles, or molecules, of air against one another and, of course, they push back. If you blow too hard and the push becomes too great, the rubber breaks. The force of compressed air is made to do many kinds of useful work. It holds up our automobile tires. It operates air brakes on trains and trucks, and it runs rock drills and many other machines.

Like most other substances, air expands when heated. Warm air is lighter than cool air, so warm air rises. The air near the ceiling of a room is usually warmer than that along the floor. In the story about wind, we learned that winds are caused mostly by the heavier, cool air rushing in as the lighter, warm air rises.

Fire needs oxygen. Nothing can burn without it. Firemen keep oxygen from reaching a fire by pouring water on it. They also use chemicals to put out fires. These prevent enough oxygen from getting to the fire by forming a gas that smothers the flames. Casting dirt on a small out-of-doors fire will quickly smother it.

If ever your clothing should

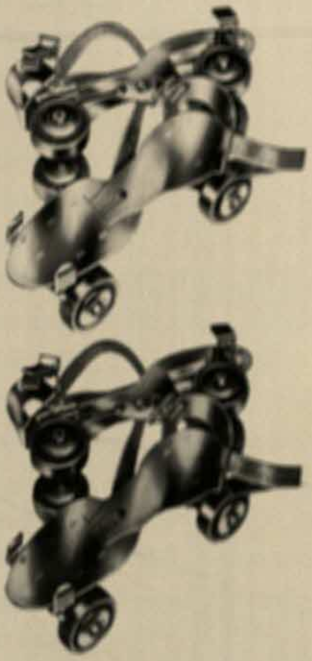
catch on fire, cover yourself up quickly with a rug or blanket. Even a coat, if used in time, might be large enough to cover the flames and snuff them out. Above all, do not run, as that only fans the flames. If you have nothing to cover yourself with, drop down quickly in a heap and try to smother the flames under you. It is hoped, of course, that none of our readers takes such dangerous chances as to play with matches or fire which every year cause many children to be seriously burned. They always think they are safe until it is too late.

If a small lighted candle is placed on a table and a glass or fruit jar turned upside down over the candle, the flame will flicker for a moment and then go out. It burns until it has used up most of the useful part of the air, that is, the oxygen, and then it cannot burn any longer. Any form of animal life put in a closed chamber will die too, as soon as a good part of the oxygen is breathed up.

You may have noticed someone blowing on a small fire or fanning it to make it burn faster. The wind created in this way supplies the fire with more oxygen. Of course, the oxygen does not burn. If it did, a lighted match would start flames all around you. But it enables other things to burn.

Some things burn easily. Some burn very little or not at all. Such things as paper and wood burn easily because the carbon in them combines easily with the air. Iron does not burn at ordinary temperatures. It, however, does combine slowly with oxygen, which is called rusting. When nails or other pieces of iron are moist they combine with oxygen more easily, that is, they rust more quickly. Tools and machines made of iron soon rust when they are left out in the rain and wind. Paint keeps the oxygen away from the iron and therefore prevents rusting.

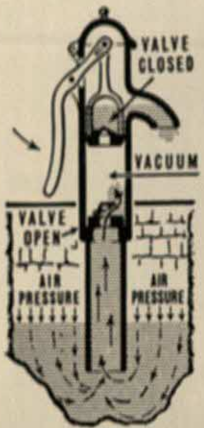
The oxygen that we breathe into our lungs combines with the food we eat in a kind of slow burning process. This process keeps us warm and provides us with energy. After great exertion we often find ourselves breathing quickly and hard. It is a sign that we are in need of more oxygen.

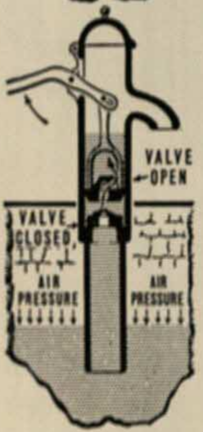


Air has weight. This you readily can discover by weighing a spare tire when it is soft, and then weighing it after it has been inflated with air. At sea level, a cubic foot of free air, air that has not been compressed, weighs 1¼ ounces. The air inside a room that is a little larger than a two-car garage weighs about 100 pounds.

This weight of air piled up for mile after mile presses down upon the surface of the earth with tremendous force. Of course, the higher you go, the less the weight of the air above. At sea level this pressure is 14.7 pounds on each square inch.

It is pushing on this page right now with a force of about 1,000 pounds or half





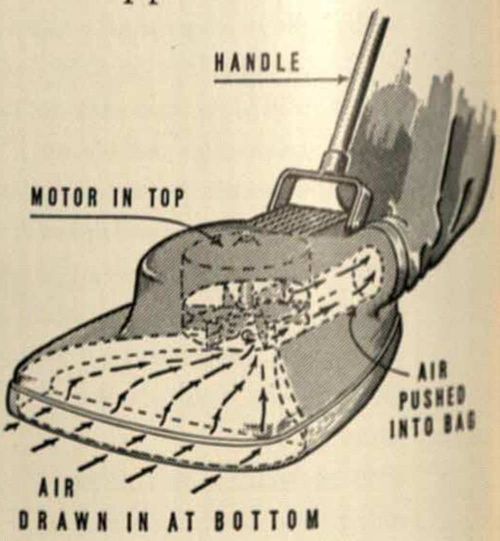
a ton. Why is it then, that you can hold the book so easily if there is such an enormous weight pressing down upon it? Because the pressure of the air is equal in every direction. The same pressure is pushing up from under the book and between the pages and in all directions around the book, so that you have only the weight of the book to hold.

We make use of air pressure in many ways. You drink a soda or some other liquid through a straw by using air pressure. As you suck the air out of the straw, the pressure of the air outside pushes the liquid up into the straw and from there into your mouth.

Have you ever pumped water from a well? If so, the chances are you used a *suction* pump. When you pushed on the handle of the pump you lifted some water out of the pipe. At the same time air pressure caused more water to rise in the pipe for you to pump out on the next stroke. The pressure of the air is strong enough so that it can push water up into a pipe to a height of about 30 feet, when the air is pumped out of the pipe.

Another use of air pressure is found in the vacuum cleaner. The motor operates a fan which pushes out air, and as it does so more air comes in through the opening at the bottom, picking up the dirt.

The pressure of the air varies from time to time even at the same altitude, depending on the weather conditions. The barometer which measures these changes helps "weathermen" forecast the weather. This is described on page 80 in the story, "How the Weather Affects Us All."



SOUNDS WE HEAR

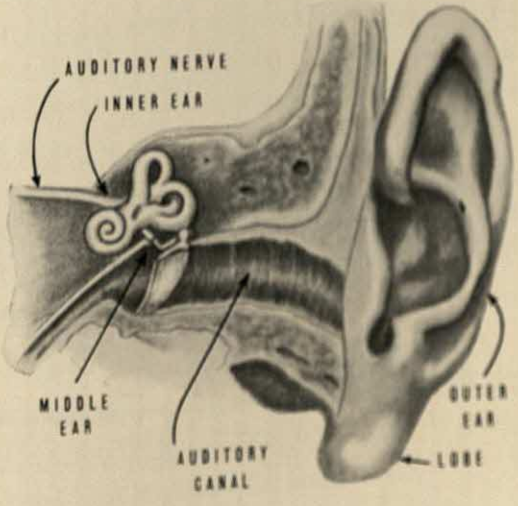
When you sit quietly and listen, you are likely to hear sounds so familiar that you do not notice them. You may hear the song of a bird or the ticking of a clock. But whether you notice them or not, nearly always there are sounds of some kind reaching your ears.

Perhaps you have wondered how these sounds occur. Every sound is made by something vibrating, that is, by moving very quickly back and forth. When a door slams we hear it because the bumping of the door against the casing causes vibrations in the wood. A piano gives off sound when its strings are made to vibrate. You hear your friend's voice because vibrations are set up in his vocal cords as he speaks. Leaves rustle because they are set to vibrating by the wind. All sounds are made by something vibrating.

But how do the sounds reach our ears? They come to us as sound waves. Whenever an object starts vibrating it causes the air nearest to it to vibrate. This in turn sets the air next to it in motion. In this manner the vibrations are passed on until they reach the air nearest our ears. Where this happens the vibrations are heard as sounds.

Vibrations go out just as the circular waves of water expand in all directions when you throw a rock into a pool. If you were to cast two rocks into the pool at the same time the waves circling out from one rock might overlap those spreading out from the second rock, but each series of circular waves would continue, even though they might get mixed up. In the same way several sets of sound waves often cross one another.

The outer parts of our ears help to collect the sound waves and direct them to the eardrum. From there the vibrations are passed



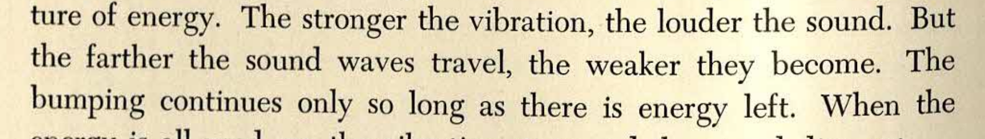
on to other delicate inner parts and finally to nerves which lead to the brain. When the message gets to the brain, the sound is heard.

Sound travels through all materials — liquids, solids, and gases. Have a companion tap the end of a table lightly with a pencil. Then place your ear at the opposite end of the table, and ask your friend to repeat the table tapping. Note how much clearer the sound seems when the ear was placed against the wood. Some day when swimming hold your ears under the water while a companion knocks two stones together in the water several feet away from you. You will hear the sound very distinctly.

Sound travels through some substances better than others. It will not travel in a vacuum or an empty space from which the air has been removed. If an electric doorbell is placed inside a sealed jar and the air pumped out, the sound will get fainter as the air inside gets thinner, although the bell can be seen to vibrate just as strongly as ever. This shows that sound waves must have some material to travel through.

Sound waves move as the molecules of air, or other substance through which the waves travel, bump one another. This requires the expenditure of energy. The stronger the vibration, the louder the sound. But the farther the sound waves travel, the weaker they become. The bumping continues only so long as there is energy left. When the energy is all used up, the vibrating stops and the sound dies out.

Sound waves travel in air at the rate of about 1,100 feet each second. The sound of a train whistle a mile away will reach your



If an automobile travels 50 miles in an hour a sound wave will travel 15 times farther in same time ears about 5 seconds after the whistle is blown. A mile in 5 seconds may seem like pretty fast traveling, but it is very slow compared with the tremendous speed of light.

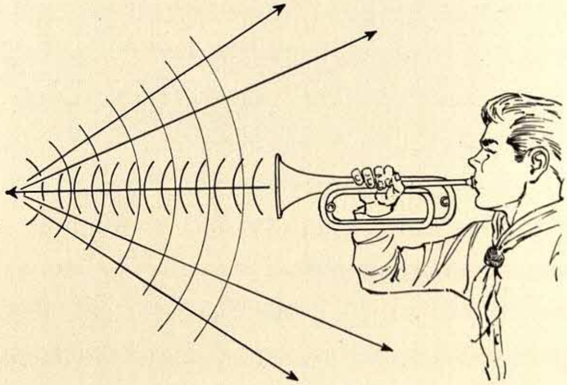
Just as you can see the puff of steam from a train whistle some distance away before you can hear the sound, likewise you can see the flash of a gun from a distance before you hear the sound of the explosion. Try counting the number of seconds from the time you see a flash of lightning in a thunderstorm until you hear the thunder. Divide this number by 5 and you will have the distance in miles to the point where the lightning struck. This simple way of measuring the distance is possible because light is seen almost instantly and it requires 5 seconds for each mile the sound has to travel.

On a warm day sound waves travel a little faster than on a cold day. For each degree the temperature rises, the speed of sound increases about 1.1 feet per second. At 32° sound travels in air about 1,090 feet per second and at 68° it travels about 1,130 feet per second.

When sound waves strike a solid surface, such as a cliff or steep hillside, some distance away, we often hear them a second time as they are reflected back to us. We call such a second sound an *echo.*

Bats make use of echoes to keep from running into obstacles when they fly in the dark. They let out shrieks which their keen ears detect, although their cries are pitched too high for human ears to hear. A similar use is made of the echo of radio waves in radar.

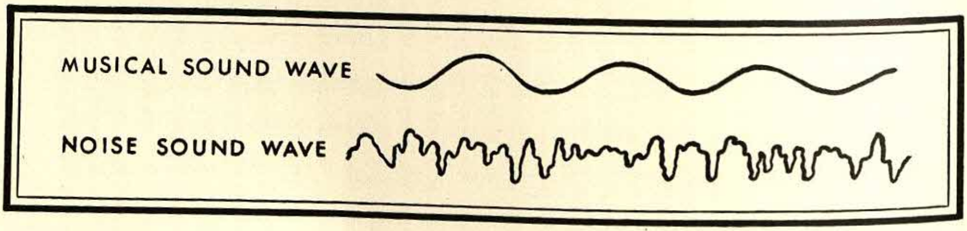
When a person shouts into a deep well or even into a barrel, a great jumble of sounds results. This is called *reverberation.* Reflection of the sound occurs over and over again as the sound waves bounce back and forth from one wall to another. Echoes and reverberation sometimes occur in large rooms and auditoriums unless the buildings are planned properly to avoid such annoyances.



Reflection of sound can be prevented. Ceilings of school corridors and classrooms are often covered with some sound absorbing material to reduce the reflection of sound. Carpeted floors, window draperies, and clothing also help prevent reflection of sound.

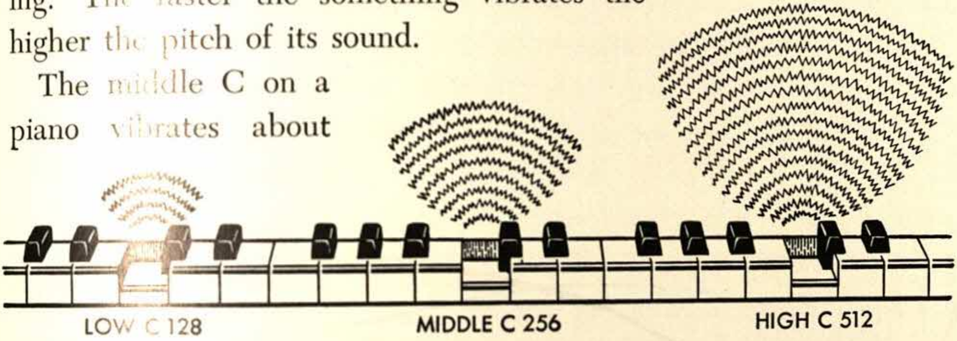
When someone drops a tin can on the floor or slams a door, we call the sound noise. When someone draws a bow across the strings of a violin or strikes the keys of a piano, we think of music. What is the difference between noise and music? It is in their different kinds of vibrations.

Scientists sometimes draw pictures to represent sound waves, even though sound waves themselves cannot be seen. The pure sound given off by a flute, for example, might be shown as a regularly vibrating smooth line. This kind of wave represents a musical sound. But the picture showing a noise is very irregular. It has no smooth curves. It is a very uneven looking line. A noise is a sound that gives off irregular sound waves. A musical tone results when a vibrating body gives off regular and uniform sound waves.



The notes played from the right side of a piano keyboard have a higher tone than those played from the left. This highness or lowness of a musical sound is called its pitch. What makes this difference in pitch? As you know, every sound is produced by something vibrating. The faster the something vibrates the higher the pitch of its sound.

The middle C on a piano vibrates about 256 times each second. The next C note above vibrates 512 times a second. The C note below the middle C vibrates 128 times a second. Some of the very lowest notes on a piano vibrate about 30 times a second. The highest notes on a piano vibrate about 5,000 times a second.



The human ear is very sensitive. Yet most people cannot hear sounds with vibrations fewer than 16 per second nor more than about 16,000 per second. There are many vibrations in the air which the human ear cannot hear.

The pitch of a note on a stringed instrument depends on the length of the string. The shorter the string, the faster it will vibrate. The pitch of a sound from a horn like a trumpet or a trombone is raised by shortening the length of the vibrating column of air.

Musical sounds also have *quality*. Although the same note or pitch is played on the piano and violin with the same degree of loudness, the two instruments do not sound exactly the same. The voices of different people do not sound alike. Different vibrating bodies produce different qualities of sound.

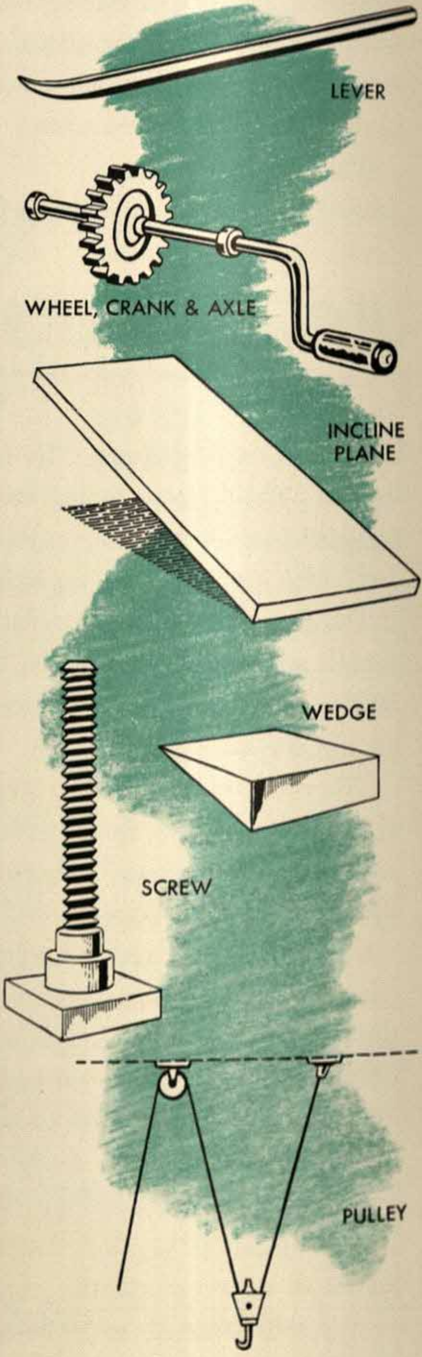
Musical sounds, then, besides having degrees of loudness, have pitch and quality. By combining these features of musical sound in many ways, musicians produce music. A great orchestra has many instruments of different quality playing sometimes in the same, sometimes in different pitches, sometimes softly, and somtimes loudly, to get the musical effects desired.

The Secrets of Machinery

ELEPHANTS are used in some countries to carry logs and do other heavy work. An elephant is so strong that it can do many things that no man can do. But we cannot have elephants to do all of the lifting and pushing and pulling that needs to be done in our modern world. Moreover, much of the work does not require such great strength; or it needs something besides strength. Neither an elephant with its trunk and tusks nor a person with his bare hands alone would do well in pulling a nail from a board, sewing a seam in a piece of cloth, or in digging a well. These are things we have learned to do by the aid of tools or machines.

When you think of machines, perhaps you think of lawn mowers or washing machines or automobiles. There are thousands of different kinds of machines. Yet, if we closely examine the parts of any of them, we will discover that there really are only a few different kinds of mechanical devices, all of which are very simple. And we find that in one way or another, each of these devices passes along a push or a pull of force.

A good example of force being passed along is in the winding of a watch. The force exerted by your fingers is



transferred along the stem to tighten the spring inside. Rowing a boat is another example. The oars transmit the pull from your arms to a push against the water. You easily can think of many more illustrations where force applied at one point does work at another.

The device may also increase the force. By pushing or pulling with a small force, it is possible to obtain a big force. An example of a machine that increases the force is the automobile jack. By operating the handle with a small force, it is possible for a person to lift an automobile—several times the weight he could lift directly. Nutcrackers and claw hammers also increase the force exerted on them.

Another type of simple machine changes the direction of the force. It is sometimes easier to exert a force in a different direction from the way you want an object to move. For example, a downward push on a pump handle will lift the water upward, and a downward pull on a rope running through a pulley will enable you to lift a heavy box to a high place.

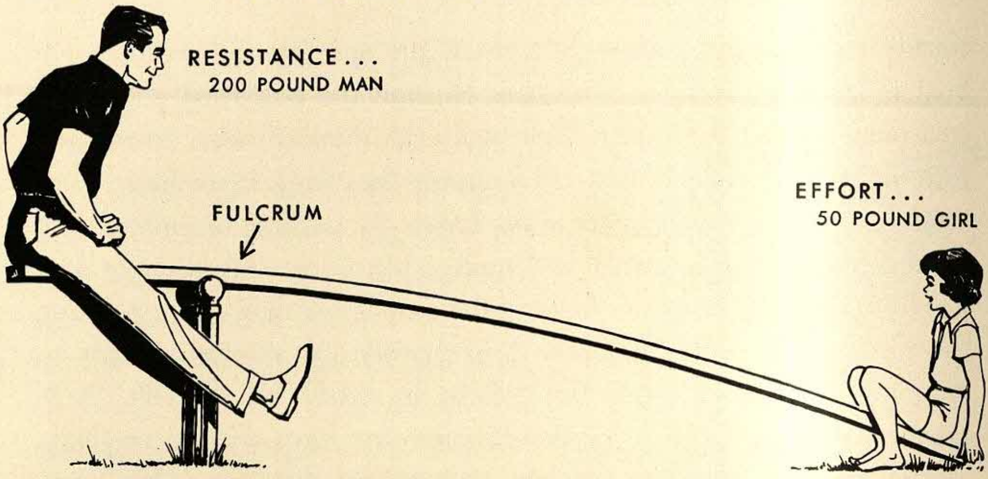
Some machines help us to apply a force at a very rapid rate. For example, with a rotary egg beater a slow turn on the handle causes the beater to turn very fast. On a bicycle, the rear wheel turns faster than the sprocket wheel to which the pedals are attached.

Nearly all machines do one or more of these four things—pass along force from one place to another, increase the amount of force, change the direction of the force, or increase the speed.

Let us examine now the different kinds of mechanical devices or simple machines that bring about these changes. There are only six—the *lever*, the *crank and axle* or *wheel and axle*, the *inclined plane*, the *screw*, the *wedge*, and the *pulley*. All machines are made up of one or more of these forms.

The simplest and probably the oldest machine is the lever. It is usually a rigid bar that is free to turn about some point when force is applied to it. Even though you did not call them levers, you certainly have used them many times. A few examples will show you how very common and useful these machines are.

A seesaw or teeter board is a lever. As your weight is pushed down on one end of the board your playmate seated on the opposite end is lifted up. To tip the lever the force of your weight not only is



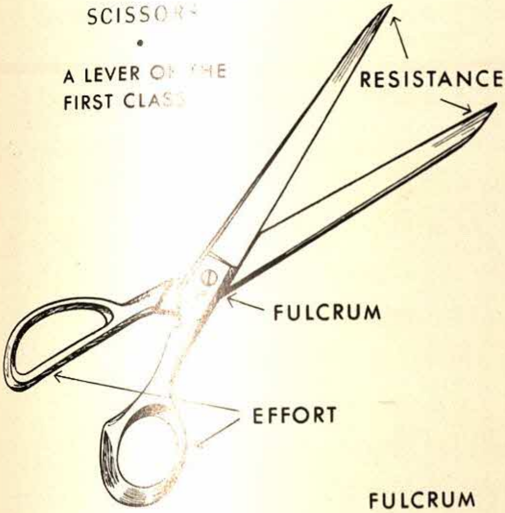
transferred to the other end, but the direction of the force is changed.

If you weigh less than your playmate you still can lift him, by having him sit closer to the center of the teeter board than you do. Even if you should weigh only 50 pounds you can lift a person weighing 200 pounds. To do this, your end of the board must be 4 times as long as his. Seated thus you will travel 4 times as far and 4 times as fast as he will. This power of your 50 pounds to lift a 200 pound weight is an example of the way in which force can be increased by the use of a lever. It also is an example of the way in which a lever can be used to increase the speed of force.

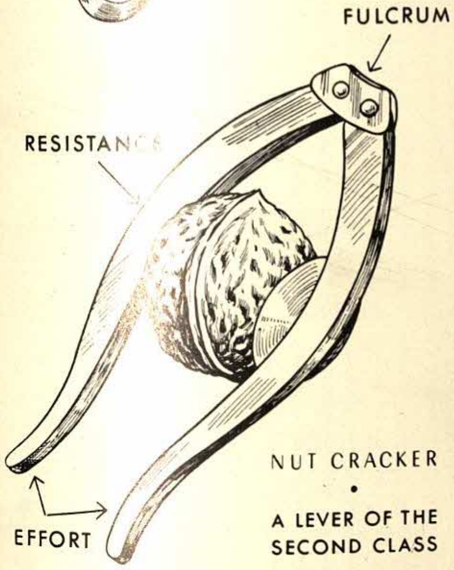
Now let us learn a few names that are used in connection with a lever. The point where the turning occurs is called the *fulcrum*. On a seesaw, this is at the bar on which the board rests. The force that pushes or pulls is called the *effort* and the object or weight being lifted is called the *resistance*. On the seesaw, you are the effort when your weight pushes your companion up. You are the resistance when his weight pushes you up. All levers have a fulcrum around which effort or force is applied to the resistance or weight.

There are three different ways in which the fulcrum, the effort, and the resistance may be arranged. Therefore, there are three different classes of levers.

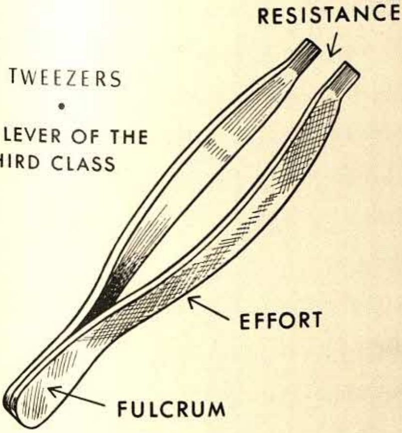
In the first class, the fulcrum is at some point between the effort and the resistance, as in the case of the seesaw. The claw hammer that you use in pulling a nail, a pair of scissors, a pair of pliers, and the hand brake on a car are a few more examples of this type of lever.



SCISSORS
•
A LEVER OF THE FIRST CLASS



NUT CRACKER
•
A LEVER OF THE SECOND CLASS



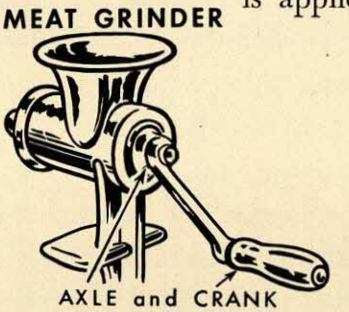
TWEEZERS
•
A LEVER OF THE THIRD CLASS

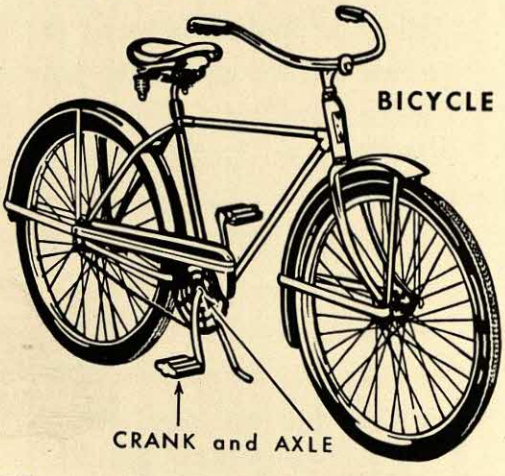
In levers of the second class, the weight or resistance comes between the fulcrum and the effort. Examples are the wheelbarrow, the nutcracker, and the oars on a boat. This type of lever, like the first, makes it possible for a small effort to overcome a large amount of resistance or to lift a heavy load. You can lift a large load in a wheelbarrow. The longer the handles, the more easily you can lift it.

In levers of the third class, the effort is applied between the fulcrum and the resistance. Some examples are sugar tongs and a pair of tweezers. Another example is in the use of a fisherman's casting rod which also shows how this type of lever may be used to increase greatly the speed of a force. In making a cast, the fisherman's elbow acts as the fulcrum, and the effort is applied by his hand near the lower end of the rod, which whips the bait out with great speed.

As you must have noticed, the type of lever which is most useful depends upon the job to be done. In the case of the fishing bait which is very light and needs speed and distance, a different kind of lever is needed than one required to pry a rock out of the ground or to lift the end of a heavy log.

The crank and axle is a special

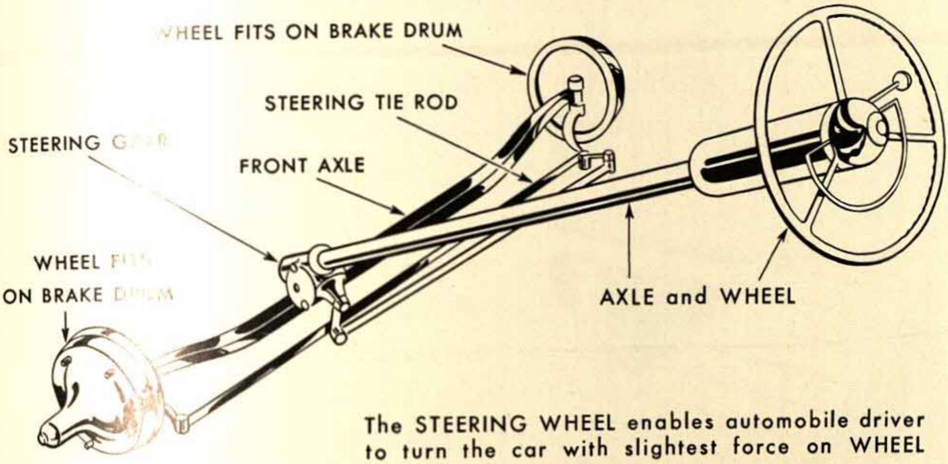




kind of lever. The place where the axle turns corresponds to the fulcrum, the force applied to the handle, the effort, and the object being turned or worked on, the weight or resistance. Just as a smaller amount of effort is needed when that effort is applied farther from the fulcrum, likewise the longer the crank, the easier it is to turn. Of course, the longer crank travels through a greater distance. A windlass is a crank attached to a drumlike axle on which a rope winds as the crank is turned. Such a machine was commonly used at one time to lift water from a well. A fishing reel is a small windlass. A clothes wringer, a meat grinder, or a bread mixer turned by hand are other examples of crank and axle machines. Whenever you ride a bicycle, you turn a crank on each end of an axle with your feet.

When a wheel instead of a crank is attached to an axle, as it is if the machine is to be run by power instead of by hand, the combination is called a wheel and axle. This simple machine has many uses. The whole wheel is really a lever, and again, the larger the wheel, the less effort is required to turn it. The large steering wheel on an automobile enables the driver to turn the car with a very slight force on the wheel. Likewise to remove a difficult screw from a piece of wood, you will need a screwdriver with a large handle.

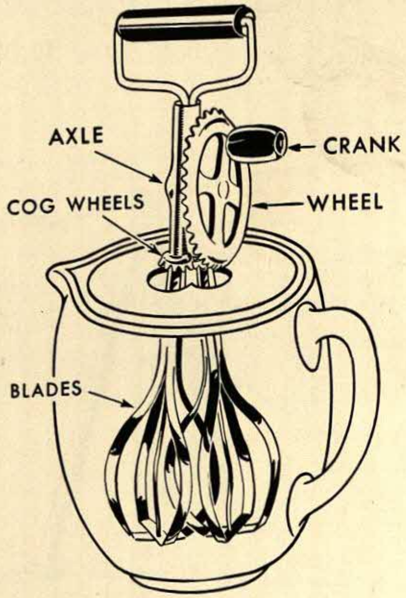
You may have noticed, when turning a rotary egg beater, that the wheels are notched. The notches of the wheel attached to the crank fit into the notches of the smaller wheels attached to the blades. Such notched wheels are called gears or cog wheels. A great many



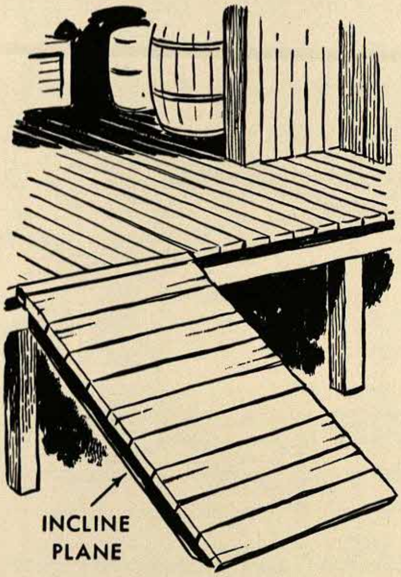
The STEERING WHEEL enables automobile driver to turn the car with slightest force on WHEEL

machines have gears in them.

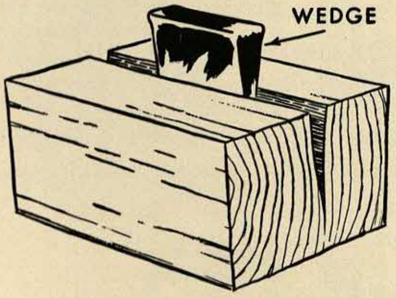
One of the most valuable types of wheel and axle is the gear. Gears enable one wheel to turn another without slipping. They are useful in changing the speed of a moving part. Some gears slow down motion; others speed it up. A large gear used to turn a small gear causes the small wheel to turn more rapidly, because each time the large gear goes around once, the small gear must go around more than once. If the large gear has 10 notches and the small gear 5 notches, then the small gear will have to go around twice while the large one goes around once. If the large gear has 20 notches to the small gear's 5, the small gear will turn 4 times as fast as the large one. Likewise, a large gear turned by a smaller one goes slower than the smaller one. Thus, motion is slowed down or speeded up according to the size of the gears that are meshed together. You will also discover as you observe two cog wheels working together that they turn in opposite directions, so another thing they do is change the direction of the force.



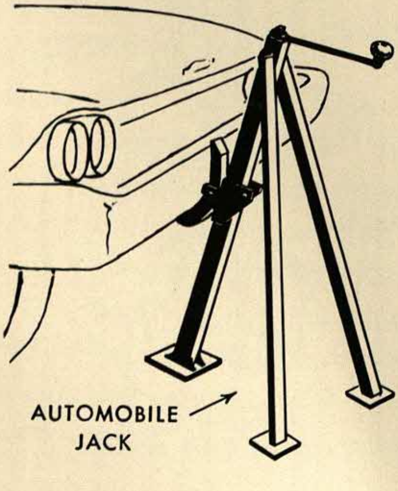
ROTARY EGG BEATER



It is easier to walk up a stairway than to climb straight up a ladder. It is easier to ride a bicycle up a gently sloping grade than a steep one. Workmen can roll heavy barrels up sloping boards easier than they can lift the barrels from the ground to a platform. Such a device for moving a load up a slope gradually to a higher level is an inclined plane. The more gradual the slope, the less force is required because the effort is spread out over a greater distance.



Another common type of machine is the wedge. It is used to fasten the head of a hammer on its handle. Wedges are used to split logs and blocks of wood. By means of the wedge, a series of small blows can be made to exert a very large force. The wedge is really a movable inclined plane. Knives, axes, chisels, and many other tools are wedges.

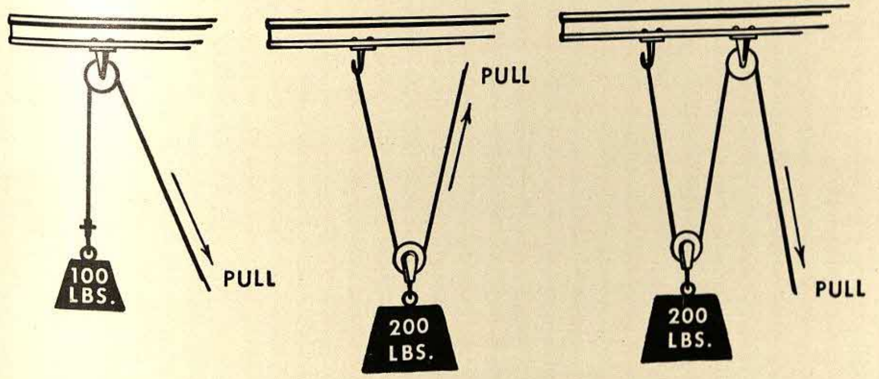


Screws are used where great strength is needed to hold materials together, as well as to lift heavy objects or to let them down gradually. The screw is a special kind of inclined plane that winds around a rod. The automobile jack, the adjustable part of a monkey wrench, and the vise are all examples of screw machines. By putting a long handle in a jack screw it is possible to lift a big weight with a small force. Of course you have to turn the jack handle several times to lift a car a few inches.

A pulley is simply a wheel that has a grooved rim in which a rope or cable can run. The rope or cable is called the tackle, and the combination of pulley and rope often is called block and tackle. Pulleys are used in many kinds of work to lift heavy loads. Elevators in buildings run on pulleys. When a pulley is attached to some fixed object, is is called a *fixed* pulley; when it is free to move with the tackle it is called a *movable* pulley.

A single fixed pulley is the simplest arrangement of a pulley. However, it only serves to change the direction of the force. One of the greatest uses of the pulley is to multiply the amount of force by using a combination of fixed and movable pulleys such as in cranes and derricks. Figure 1 in the picture shows the simple fixed pulley. A downward pull of 100 pounds just balances the 100 pound weight so it takes a little more than a pull of 100 pounds to lift it.

Suppose a man wants to lift something that weighs 200 pounds and he weighs only 180 pounds. With a single fixed pulley his whole weight of 180 pounds will not lift the 200 pounds. However, there are two kinds of pulley arrangements that will enable him to double the effect of his effort and thus permit him to lift 200 pounds with the same pull that it takes to lift 100 pounds with a single fixed pulley. If he can get to a platform so that he can pull up instead of down, a



Each of these weights can be lifted with the same amount of force.

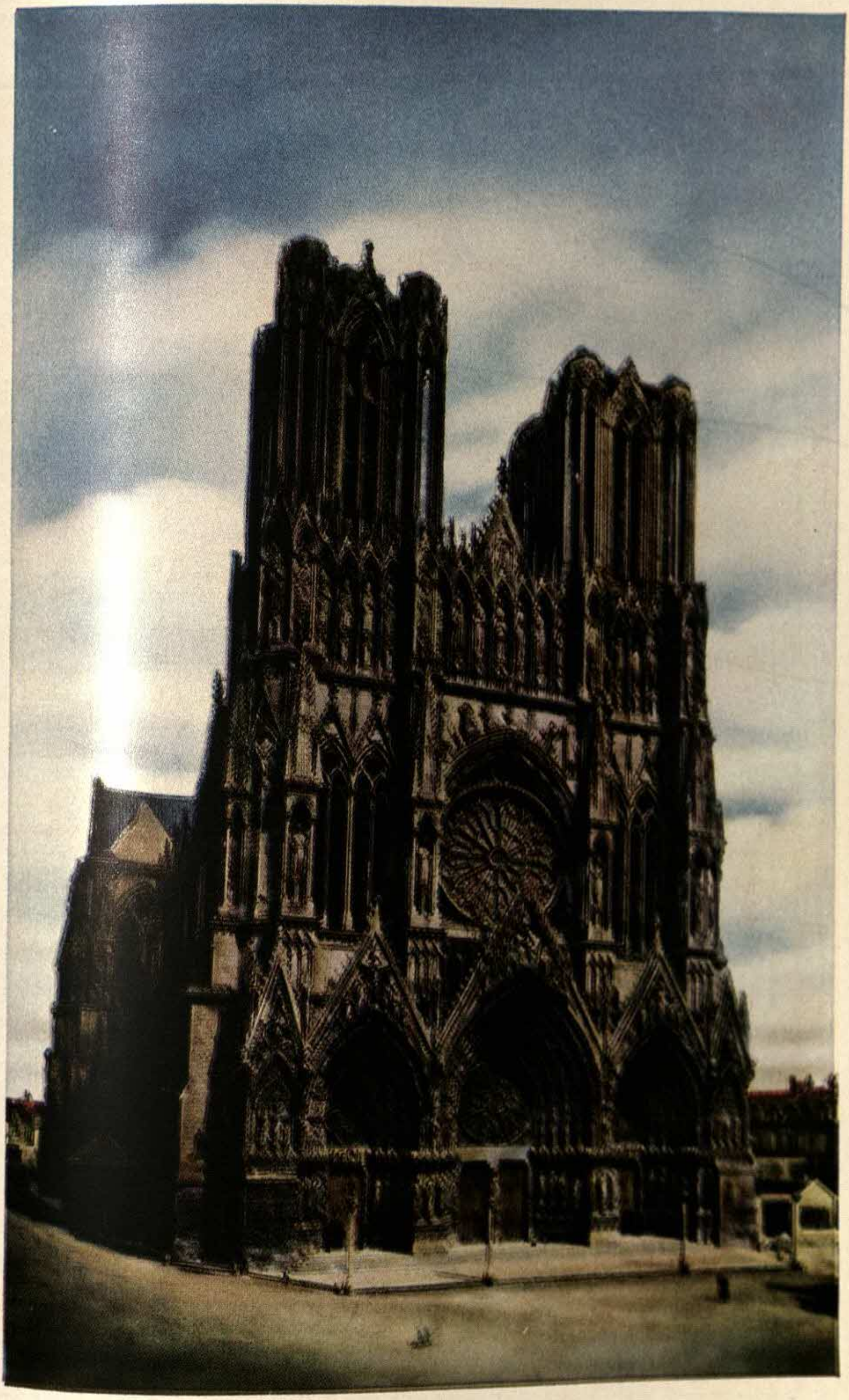
single movable pulley as shown in figure 2 will answer the purpose. The end of the rope attached to the fixed object overhead holds one-half of the weight. Thus the man has to pull only the other half. However, he must pull rope equal to twice the distance that the weight travels, because the force has to travel twice as far in order to double its effect.

Another way the man can lift the 200 pounds with a 100 pound effort is by adding the arrangement shown in figure 1 to that seen in figure 2, to produce the combination shown in figure 3. Its use involves standing on the ground and pulling down in the same way as in figure 1. Thus by using more pulleys, in a proper arrangement, the force can be multiplied to such an amount that very large weights can be lifted with a reasonably small amount of effort. This arrangement of pulleys is very useful in steam shovels and in other hoisting devices. Without it the engines or motors would have to be much larger in order to lift the huge loads that they sometimes carry.

Let us now examine a complex machine to see how it is made up of simple machines. The steam shovel is a good example, because it includes, in some form, every one of the different kinds of simple machines. The huge swinging crane of course is a lever. There are wheels, axles, gears, and pulleys. The blade of the dipper is used as a wedge for it cuts into the dirt, and the bottom of the dipper is an inclined plane as the dirt is scooped up. Some of the adjustments in the machinery are made by screws, and screws and bolts are used in many places to hold the parts together.

A watch is a complex machine. It has many parts. But each one of them by itself is quite simple, a wheel and axle, a lever, or a screw.

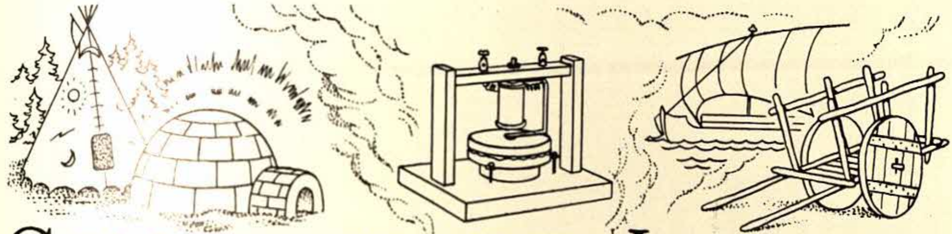
Probably the first machine ever devised by man was a lever. Its discovery may have occurred when man used a pole to pry loose a rock that he was unable to lift. He took a much greater step forward in his conquest of the world when he invented the wheel and axle. After that people could move things without dragging them over the ground or carrying them on their backs. Modern forms of transportation and many other machines are built more or less around some form of the wheel and axle combined with one or more of the other types of simple devices described in this story.



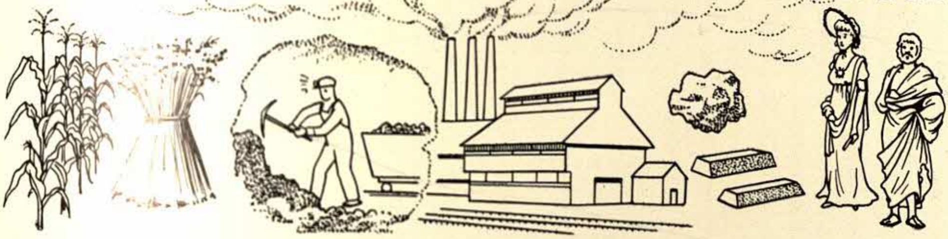
When man learned to live in communities he was freed from spending all his efforts and time wandering about in search of the bare necessities of food, shelter, and clothing. This freedom started him thinking and acting beyond the simple needs of keeping alive. It caused him to set up altars and temples.

As man progressed his beliefs changed, and his temples grew larger and more splendid. None are more beautiful than the Gothic cathedrals built in Europe during the Middle Ages. The cathedral at Rheims, France, seen in this picture, is one of the most beautiful although it has required extensive repairs after each World War.

Every detail of a Gothic Cathedral symbolizes the faith of its builders. Its arches, ceilings, doorways, and windows point to the skies. Entire communities often worked for centuries to build one of these great churches. Those who had no money gave their labor. Frequently they harnessed themselves to carts, filled with bricks, mortar, and stone, singing chants as they pulled the great heavy loads.



COMMERCE AND INDUSTRY



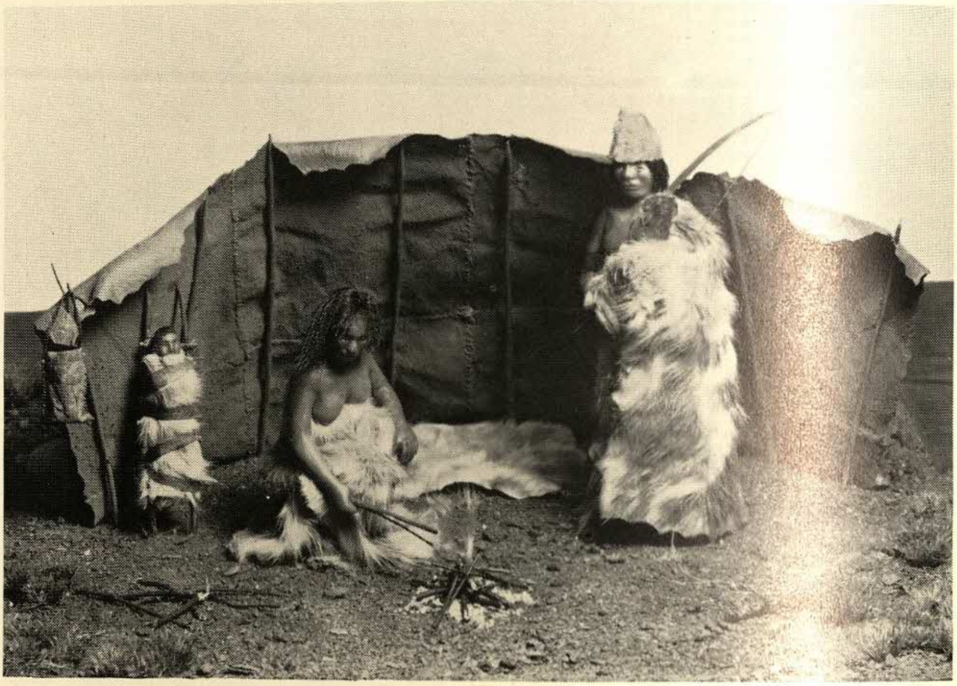
THE STORY OF SHELTER

THERE IS no record old enough to tell us who built the first shelter. Undoubtedly thousands of times in thousands of different places early prehistoric men felt the need of escaping from the heat of the sun or the drive of the storm. They huddled under trees or in thickets or used whatever was at hand to protect themselves.

Some shelters were fashioned by sticking branches into the ground and lacing other branches in and out among them. Other shelters were made from skins tied to sticks set into the ground.

Of course such shelters were only crude screens or windbreaks. But even today the natives of Tierra del Fuego, and several other modern primitive peoples still live under such windbreaks. At no time have they attempted to build anything that resembles a house.

Probably the first house that man lived in was a cave. Certainly it was a natural abode for one who spent most of his day prowling about in search of food. Because such shelters were not to be found everywhere, in some parts of the world early men dug and carved out rooms in the sides of cliffs. They usually made the entrances several feet above the ground, using ladders, often made of woven vines, to get in and out of their dwellings. Those ladders were pulled up when not in use, in order that the cliff dwellers might secure safety from possible enemies.

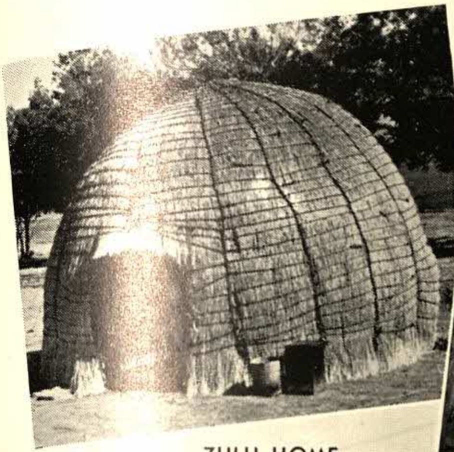


A WINDBREAKER on the island of Tierra del Fuego

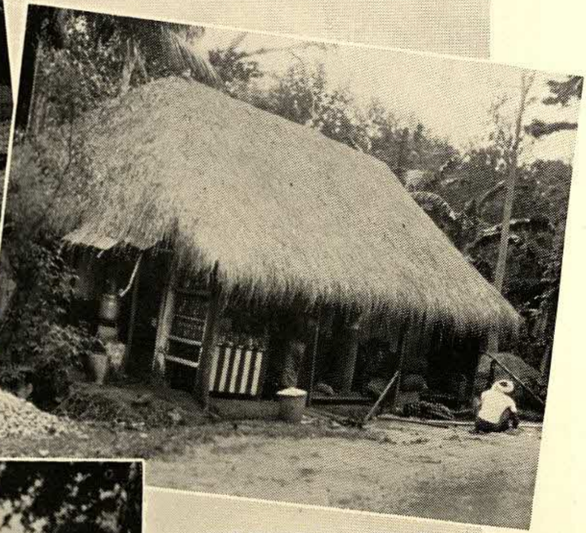
As long as man depended entirely upon hunting for his living he could well use caves and dugouts. But after he had learned to tame animals and accumulate them in flocks and herds, he was forced to live wherever he could find grazing lands for them. He used skins for a cover as he stretched out on the ground to rest. Later he sewed skins together and hung them over a pole to make a tent. In time he learned to set a pole at each corner of a square with a taller one in the center, and spread overhead a covering for a roof. Such a tent, really one of the first forms of a house, could be taken down quickly and set up again at the next stopping place.

Tents made from the skins of their flocks were the only dwelling places Abraham and Isaac and Jacob knew. And the Bedouin Arab today still pitches his tent wherever he decides to stop on the desert, and rolls it up again whenever he is ready to move.

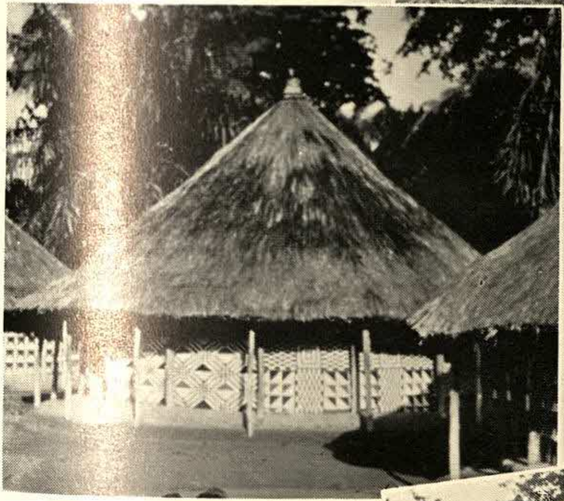
About ten or twelve thousand years ago man learned to sow the seeds of grasses in the fertile river valleys and to harvest them in due season. As a farmer he found it best to settle down in one place. For the first time man was faced with the need of a fixed abode in which he and his family could dwell and store his possessions. His



ZULU HOME

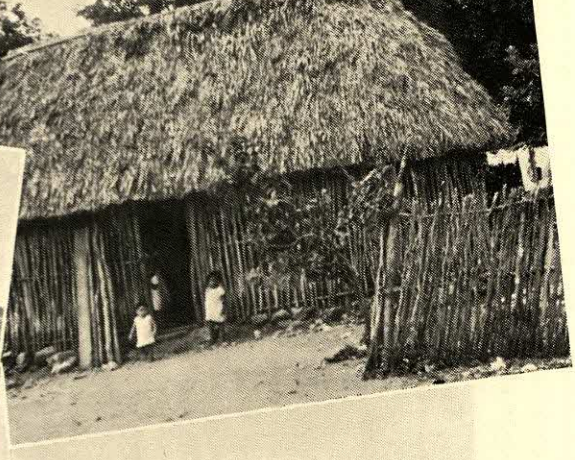


INDONESIAN HOME

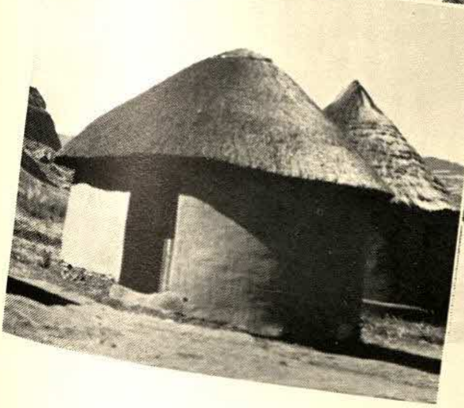


MANGBETU HOME

MAYA HOME



SOUTH AFRICAN HOME



fumbling efforts to build a home were the beginning of the many kinds of buildings which we have today.

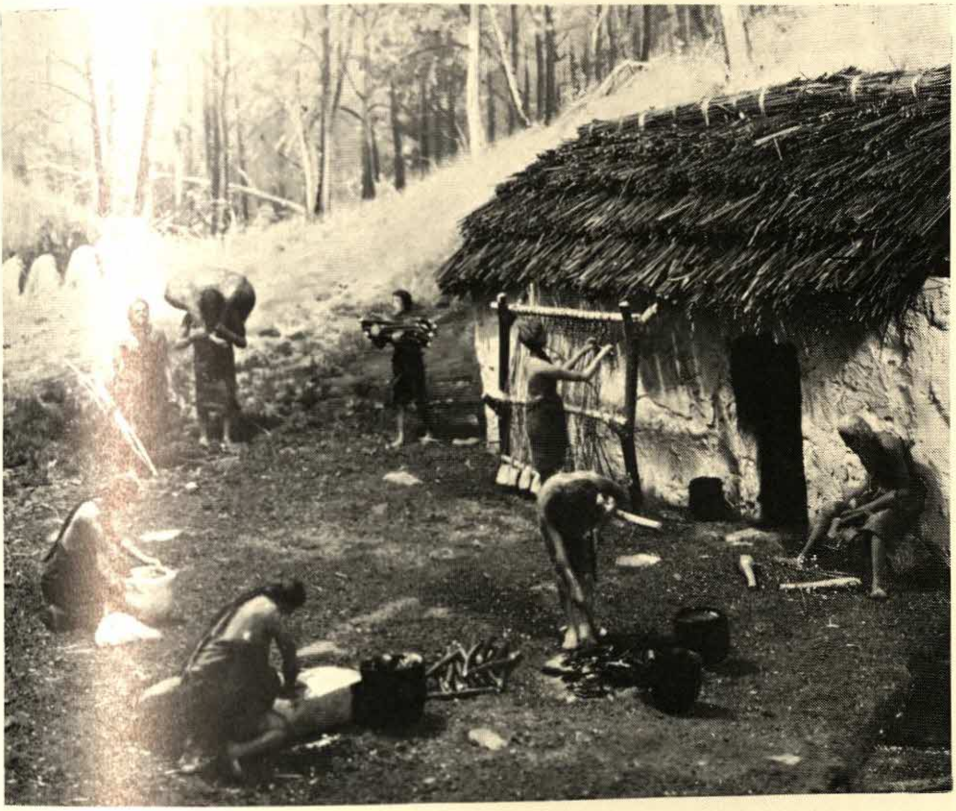
There is little in the world that has not undergone growth and change. So too, man and his ways of living have a long story of development behind them. Houses did not suddenly come to be. Their builders, like inventors, began where others had left off. Using this knowledge of what had begun before, they gradually invented new forms and made improvements in the old.

The first building must have been an enclosed space with a roof, because there is no way to build a room except with walls, and no way to keep out the weather except with a roof. A few long branches set in the ground, perhaps in a circle, with the tops bound together, would provide the framework. A hole could be left at the top out of which smoke might rise from a fire. Then the framework could be thatched by weaving grasses in and out among the branches, leaving an opening at one side for an entrance.

The African Zulu builds his thatched dome-shaped hut today in such a manner. So do many other modern primitives. An excellent way of learning how prehistoric people built their shelters is to study the homes of modern primitives in different parts of the world. They are built much as their ancestors built them thousands of years ago.

As wood was used in the forested regions, clay and mud had to be used in the places where there were few trees. Among the earliest places where man settled was the valley of the Tigris and Euphrates rivers. In ancient times that region was called Babylonia. There on the treeless plains man, in need of building material, noted the way in which the heat of the sun baked the soft mud into something like stone. So he began to shape chunks of mud into bricks and dry them in the sun. Before long he had learned to stiffen the bricks by mixing straw with the clay.

Clay has been used, too, for centuries, in the construction of wattle and daub dwellings. The walls of such shelters are made from the branches of trees interwoven with twigs, reeds, and grass called wattle, and daubed, or plastered, with clay. Many of the thatched wattle and daub cottages which may be seen in various parts of Europe today have been plastered both inside and out with clay.



A WATTLE and DAUB dwelling

Wherever stone was abundant, man has made use of that in the construction of his buildings. Among the ancient builders to leave great structures of stone were the Egyptians. They were the builders of the Pyramids, each pyramid being the tomb of a king, or pharaoh, as the ruler of Egypt was called. By that time man was no longer an awkward groping worker. He had become a skilled craftsman.

Thus it was that through the ages man learned to build not only great buildings but great cities and empires. One after another, Babylonia, Egypt, Greece, and Rome rose to great heights. As they fell back, their works were largely demolished, but still the knowledge and skill of building lived on.

The Europeans who first discovered and explored America found the Indians living in primitive shelters. Their dwellings were constructed of the materials at hand, and varied according to the skills and the needs of their owners. The tribes that roved the Great Plains in search of herds of buffalo erected light skin tents called tepees. Other tribes living in the wooded regions of the country depended upon bark to cover the framework of their wigwams. Those who were farmers built more permanent dwellings such as the long houses of the Iroquois and the pueblos of the Hopi.

The first American colonists built small log cabins with tamped earth for floors and greased paper for window panes. But as soon as possible they began to construct houses more like those they had known in their native countries. Many of them were skilled craftsmen. And so it was that America came to have Spanish houses in Florida and Louisiana, Dutch houses in New York, and various types of English homes in most of the thirteen colonies along the Atlantic Coast. It was Thomas Jefferson who introduced the Greek and Roman style of building in America with his home, Monticello.

Colonial styles of architecture often are used today in designing houses. However, many other influences such as the Swiss, German, Russian, and Scandinavian are to be found in the styles of buildings in various sections of the United States. All styles have marched westward with the settlement of the country.

Man was content with one, two, and three story buildings until the beginning of the Machine Age when great numbers of people began living in the cities. Apartment buildings were erected to accommodate the greater number of families who wanted to live close to their work. The skyscraper, also, became a familiar building in business and industrial centers. Such tall buildings were possible because of the availability of steel for structural purposes.

Today man is not dependent upon the region where he lives for material to build his house. Transportation makes almost any material available. Neither is he dependent upon his own efforts to construct his shelter. He can call upon architect, contractor, electrician, interior decorator, painter, and many others to help him plan, build and furnish his home.

Every building tells its own story. It speaks of wood and stone, of marble and brick; it speaks of style and workmanship, of builder and purpose. But more than that, it speaks of the people who live within. Much of the history of any community could be written from the story of its buildings.

THE STORY OF FOOD

The Gleaners—a famous painting by Jean Francois Millet

SOMEWHERE in man's early history, he learned that the best way of securing a good supply of food was by sowing the seeds of plants and cultivating the soil. That discovery changed his whole manner of living. Instead of roving the countryside in search of food for himself and his flocks and herds, he was able to settle down in one place. He then discarded his tent for a permanent shelter. He acquired neighbors, built towns and temples, and found time to develop ways for making life more pleasant. It was the first farmers who really took the first steps toward civilization.

Ever since, man has relied upon cultivating the soil for most of his food requirements. Not only does this yield cereals, fruits, and vegetables for himself, but it produces plant foods for the animals upon which he depends for most of his meat supply.

First in the list of plant foods are the grains from which most of our cereal foods are obtained. Barley, corn, oats, rice, rye and wheat are the leading cereals. Wheat is probably the oldest and most important. It has had a place in man's diet for thousands of years.

The two greatest wheat growing regions in the ancient world were those where our civilization started, Mesopotamia and Egypt. From those countries the raising of wheat spread to Greece and Rome, then northward to other parts of Europe and eastward to Asia. Not until European colonists brought wheat seeds with them was there any wheat raised in the Western Hemisphere.

The wheat which is grown today is not like that grown in ancient times. In those days it was a delicate plant, easily ruined by frost, drought, and disease. As its cultivation spread over the earth the wheat plant adapted itself to different climates and various soils.

About one hundred years ago, Mendel, an Austrian monk, began some scientific experiments with peas. He wrote an account of what he learned. No one paid any attention to it at first, but thirty-five years later scientists began some experiments to carry on the work started by the Austrian monk. Since then, his discovery, now called the *Mendelian Law,* has been used to produce more and better wheat, as well as other food plants. Due to Mendel's work and that of scientists who have followed him, wheat flourishes today in countries where it never could grow before.

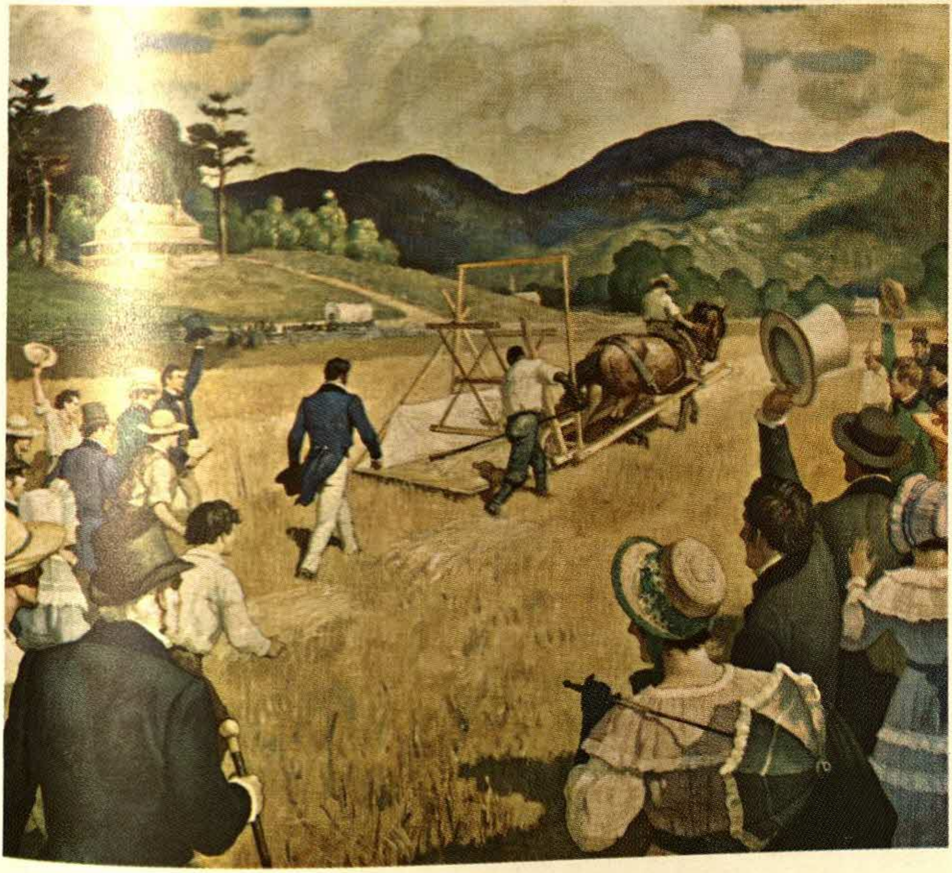
Without farm machinery the present tremendous production of food would not be possible. Until the early part of the nineteenth century, most of the work was done by hand. Even after the first metal plow was invented, the farmers were slow to use it. It took them time, too, to see the advantages of Cyrus McCormick's reaper. But once they accepted farm machines they began demanding more and better ones. Today on large modern farms motor-driven gangplows and other attachments prepare the soil; power drills plant many rows of seed at one time; and at harvest time huge combines cut, thresh, and clean the grain in one operation.

One improvement often calls for another. As soon as the farmers were able to grow more wheat they needed better ways to get it to market. Railroad building was hastened, and great storage elevators were built. Cities like Buffalo, Chicago, and Minneapolis became central places for the collection of wheat and the making of flour.

All this has taken place in order that man may have bread. No food ever has surpassed it in general use. Because it appears daily, in one form or another at almost every meal on the tables of the great masses of people of the world, outside of the rice eating regions of Asia, it is often called the "staff of life."

No one knows who first learned how to bake bread. Perchance one day a primitive man while pounding wheat seeds into flour was forced to leave his task. Before his return rain had fallen on the flour and the sun had baked it into a cake. Being hungry, the man tasted it, found it good, and decided to do some baking, using his own crude methods. Undoubtedly the first oven was merely a rock laid in a fire to make the wheat cakes dry faster.

The Greeks were the first people to have public bakeries. The Greek bakers taught the Romans. Gradually the knowledge of breadmaking spread throughout Europe. However, the masses of Europeans



The first public test of McCormick's reaper was held in Virginia, July, 1831 did not have wheat flour. They used rye, oats, and barley. This often was combined with ground-up roots and acorns, making a very dark kind of bread.

White flour such as that which we have today was unknown because there were no mills capable of making it. However the Egyptians and later the Romans, by a process of sifting or bolting, managed to produce a flour that was fairly white. The church influenced the production of white flour because the clergy wanted white bread for religious ceremonies. Once the nobility had tasted the white bread they wanted it on their tables. Thus it was that the eating of white bread was associated with wealth and position.

It was only after the invention of modern milling machinery that white bread became a commonplace food. Of all the breads that are made, white bread still remains the favorite. However, in milling white flour, the light golden skin of the wheat seed, called bran, is removed. This removal means a loss of some of the valuable parts of the grain, substances which are important in the growth and health of man and other animals. Chemists speak of these losses as vitamin and mineral losses. Modern millers and bakers often add some of the vitamins and minerals to their white flour or bread mixture. This process is called enrichment.

Through centuries of breadmaking, many countries have developed their own special kinds of breads. Among them are English muffins, Mexican tortillas, Russian dark sour rye bread, German zweiback, Danish pumpernickel, and Scotch oat cakes. Some forms of bread that are particularly American are baking powder biscuits and corn bread.

Not all the wheat is used to make flour for breadmaking. Breakfast cereals take a great share of the wheat grain because much of the corn is used to feed cattle and other animals.

Corn, called maize by the Indians, was an entirely new kind of grain to the first European settlers in America. Those early colonists considered it inferior to the old world cereals. But in their struggle to survive in the new land they learned to like it. Many times it was corn that saved them from starving. Today corn is raised in many countries, but most of it is used to feed livestock.

At first man planted only the seeds of plants native to the region

Male date flower alone has odor inviting bees, so it is vital to collect its pollen and pollinate each female blossom by hand

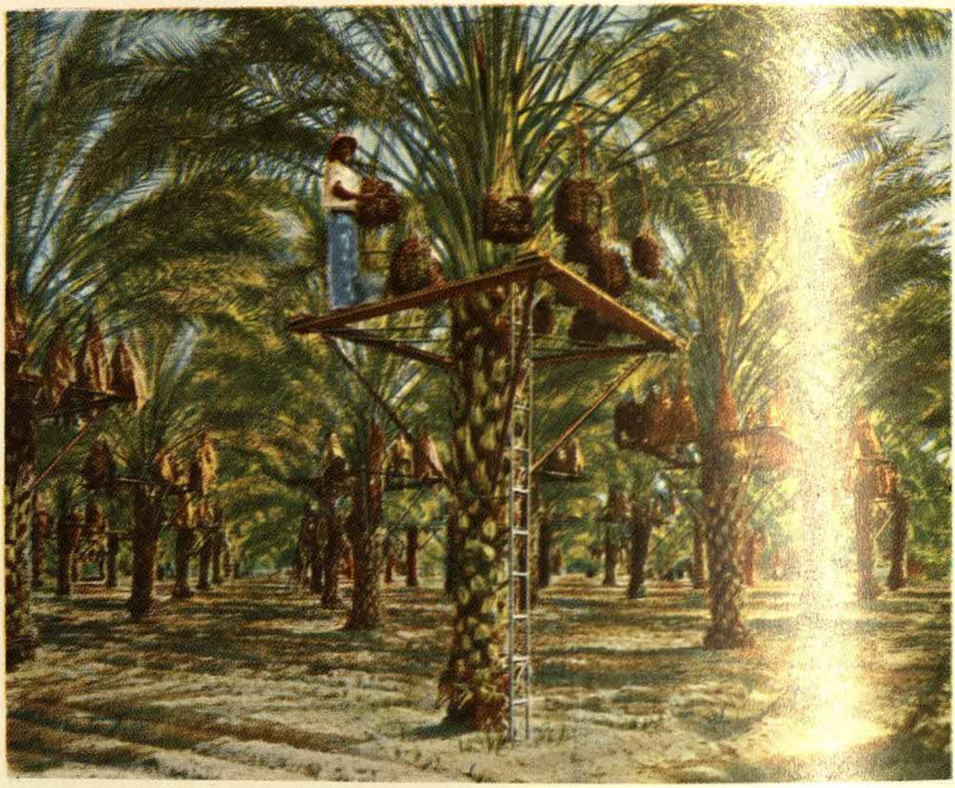
in which he lived. Gradually he became aware of the value of plants growing in other communities. As time went on, many plants were spread from region to region and even from one continent to another.

Originally rice was grown only in China and other parts of the Orient, where it long has been the main food of many people. In the Middle Ages it was brought to Spain by the Moors. Still later it was taken to America by European colonists. Now large quantities of rice are raised in several of the southern states.

Many of our common vegetables originally came from the Old World. Among them are the artichoke, asparagus, bean, cabbage, carrot, cucumber, cauliflower, celery, egg plant, lettuce, parsnip, pea, okra, oyster plant, spinach, soybean, and turnip. Others like the white and sweet potato, tomato, squash, pumpkin, pepper, and lima bean are native to America.

Fruit probably was one of man's first foods. At certain times it was fairly easy to obtain as he traveled from place to place. Although early man had no idea of spreading the growth of the fruit he ate, he did so when he devoured the pulp and tossed aside the seeds.

Our most common fruits such as the apple, the peach, the pear, the plum, and the cherry, were eaten by people living in the Old World centuries before America was discovered. The early colonists planted the seeds of those fruits rather than the ones of the wild varieties they found growing here, because centuries of cultivation had made



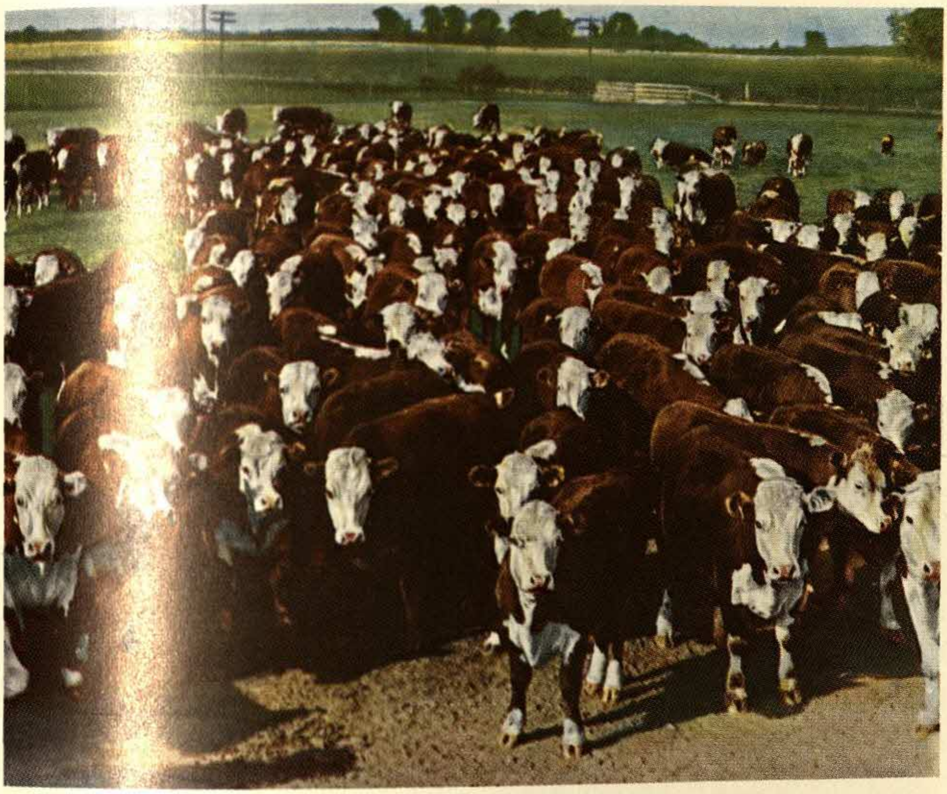
The dates are picked individually from permanent platforms

the Old World fruits larger and sweeter. From those first seeds, hundreds of American varieties have been produced.

The natives of the desert areas of North Africa have depended largely upon the date for food. For centuries this fruit has been exported to Europe and America. Now excellent American dates are grown in irrigated desert valleys such as the Coachella and Imperial Valleys of Southern California.

Man demands meat with his grains, vegetables, and fruits. Great herds of cattle, droves of sheep and swine, and flocks of chickens, ducks, geese, and turkeys are raised each year to fulfill that demand. Along with the beef, lamb, pork, chicken, and turkey, man consumes quantities of cod, salmon, tuna, and other kinds of fish.

At first people had few ways of preserving food for future use. They salted and dried certain kinds of fish and smoked or spiced various types of meat. Later they learned how to can foods, and still later how to keep them fresh by refrigeration long enough to reach distant markets.



Great herds of cattie are raised to meet man's demands for meat

Then came Clarence Birdseye of Gloucester, Massachusetts, who had watched the Eskimos freeze fish and meat. He applied quick-freezing to fruits and vegetables. Now due to this wonderful method of preserving food it is possible to have many kinds of fish, meats, vegetables, and fruits the year around in practically as good condition as when they were fresh.

Man lives chiefly on the products of agriculture. When crops fail he faces hunger and sometimes starvation. Many men since Mendel have devoted their lives to the study of soil and plant breeding in order to produce better varieties of plants. Among them were Luther Burbank who performed wonders with certain vegetables, fruits, and flowers, and George Washington Carver who found hundreds of ways to use the peanut and the sweet potato.

Problems of food supply have sometimes caused wars and influenced world events. It was the need for spices that led to the search for a new route to India, and eventually to the discovery of America.

THE STORY OF CLOTHING

NO ONE knows whether the first clothes were worn as ornaments, or as protection to the body. Quite likely some of the early men tossed the skins of wild beasts over their shoulders to show their skill in hunting. But there hardly can be any doubt that in the cold regions of the earth they used some of the shaggy pelts of the animals they killed to protect themselves from the weather.

One of the tools used in the Stone Age was a sharp-edged scraper. It was used to remove the flesh from the skins of animals. After the scraping was finished the skins were rubbed with fat, then hung over a fire and smoked. This made them dry, strong, and pliable enough to be shaped into the form desired.

The American Indians prepared leather from deerskin in much the same way. From it they made moccasins and other articles of clothing.

The Eskimos have been making garments of fur for a very long time. The skill of an Eskimo woman in making a fur suit, using animal sinews for thread, is remarkable. At the time the white man found them, the Indians and Eskimos had progressed a long way beyond the primitives who merely wrapped themselves up in skins to keep warm.

Some of the early traders who came to America from Europe came for the wealth of the fur-bearing animals here. Nowadays in many civilized countries fur often is used to make entire garments or for trimming.

Leather, which is simply the hides of animals properly prepared by a process known as tanning, is still an important clothing material. While it is used chiefly for making shoes, there are other important uses such as for belts, gloves, and certain types of jackets. The ancient Egyptians were among the first to make fine leather.

The first clothing of those living in warm climates probably consisted of grasses and leaves, or pieces from the bark of trees. Even to this day clothing varies from place to place. Still it does not always hold true that little clothing is worn in the hot climates of the earth, and warm clothing in the cold areas. The natives of cold, windswept

Tierra del Fuego wear little or nothing, while the Arabs wear long, heavy robes and turbans.

We do not know when or where man got the idea of making cloth. At the dawn of history he knew how to spin and weave wool, flax, cotton, and silk. For centuries he made fabrics from these four fibers, without finding a suitable fifth one.

At first cloth was worn as it came from the loom. The strip of goods was folded or wrapped around the body in various ways. Sometimes it was draped about the shoulders, sometimes around the waist. Thorns, fishbones, or narrow strips of fabric were use to hold the garment in place. Sometimes the upper part of the fabric was knotted or pinned over one or both shoulders.

Even to this day in some countries, such as India, women completely, and often beautifully, too, dress themselves in one long piece of cloth. First the length of cloth is folded in a manner to form a skirt, and then it is wound about the shoulders. Frequently one end of the cloth is

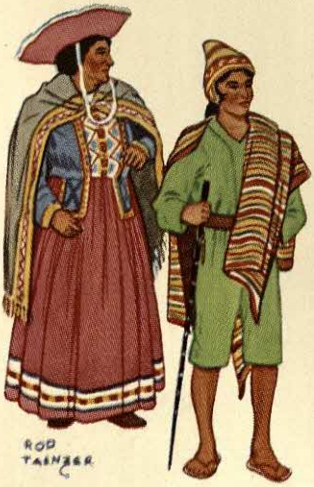
Guatemalan Indians weave beautiful cloth on their hand-made looms thrown over the head to make a sort of hood.

Many of the early weavers, like the Peruvians, cut a hole in the middle of a long strip of cloth to make a garment called the poncho. After the owner had slipped his head through the hole he tied the single piece dress into place with a belt. Sometimes the sides of the poncho were sewn together under the arms to form a shirt. The poncho still is worn in some parts of South America.

In temperate climates where the weather is likely to be hot one day and cold or rainy the next, or where it gets hot in the middle of the day and cold at night, people need extra garments which can be easily discarded. Many an American Indian wore only a breech cloth when the weather was warm and only drew a blanket or robe around him when the weather turned extremely cold.

Costumes often seen in India

The first records of the use of definite costumes were found in the tombs of the ancient Egyptians. Many types of dress have been developed since those early Egyptian garments. Some of them were extremely simple in style as, the two important garments of the Greeks, the tunic and the mantle. Others, like the gowns worn by Queen Elizabeth of England, were



The Peruvian poncho

American frontier

French—early 19th century

very elaborate. Some were easy to wear, and others most uncomfortable.

Fashions are determined by many things. Often it is the surroundings in which people live that determine their choice of clothes. There is not a single garment in the entire outfit of a cowboy that is not useful to him in his life on the plains. Other styles may be designed to indicate the rank of the wearer or just to suit some person's whims. It is said that long, hanging sleeves became the fashion in Anne Boleyn's time because she wished to hide a deformed little finger. The fad for wearing starched and pleated ruffs during the reign of Queen Elizabeth started with a Spanish princess who wished to conceal a goiter.

Although climate and environment have played important parts in dress, most of the changes in clothing have come through improvements in the manufacture and use of woven fabrics, or textiles.

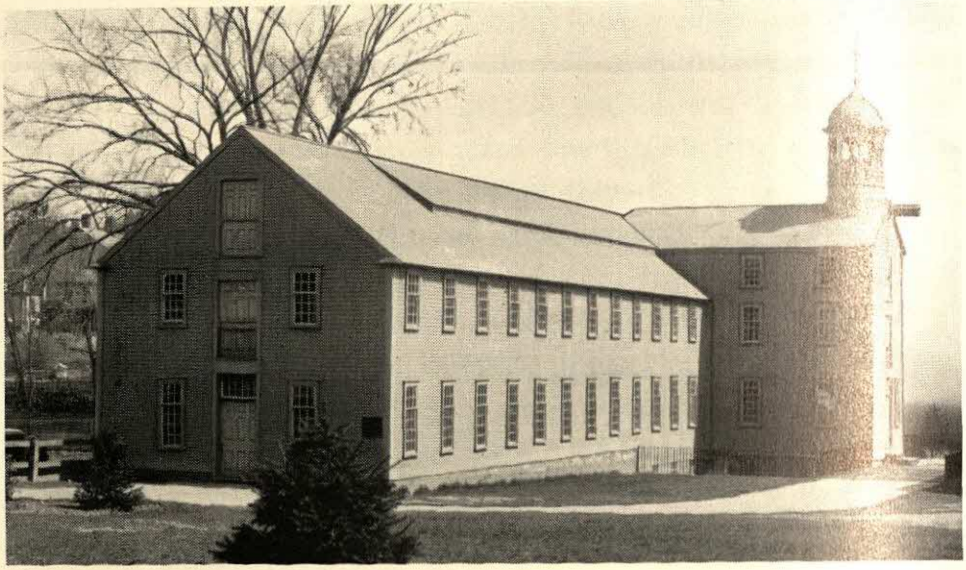
Cotton was first used for making cloth in India. Early traders found a ready market for this cloth among the people living near the Mediterranean Sea. At that time the Egyptians and their neighbors were familiar only with linen and wool. Whenever they spoke of the

Costumes often seen in China

Cool and simple Egyptian

Greek peplos and himation

Time of Queen Elizabeth



Samuel Slater's old textile mill in Pawtucket, Rhode Island

cotton cloth those early traders called it vegetable wool.

Centuries later the colonists of Virginia began to grow cotton. But its use was small, due to the fact that the fiber clung tightly to the seeds. Separation of the two had to be done by hand. Eli Whitney put an end to the slow and tedious work of cleaning the cotton when he invented the cotton gin in 1793.

About this same time Samuel Slater set up the first American textile mill in Pawtucket, Rhode Island. With the coming of machinery many changes took place. More goods could be produced at a much lower cost. Prices of cloth came down. No longer was it necessary to do spinning and weaving in the home.

Still all the sewing had to be done by hand. The first person to try to make a sewing machine was an Englishman named Thomas Saint. But it was not until Elias Howe, an American, patented a new and better machine that sewing machines came into general use.

Cotton has played an important part in the development of the United States. Large quantities of it are produced in India, China, Egypt, Mexico, Brazil, and Peru. Ever since the first textile machines were invented in England, that country has imported a large part of the world's supply of cotton, and manufactured it into cloth.

Cotton can be produced in greater quantities and at less cost than any other textile. In all the warm regions, and during the hot seasons elsewhere, it is better than wool for most articles of clothing. Some of the fabrics made from it are broadcloth, calico, canvas, cheesecloth, corduroy, gingham, khaki, lawn, muslin, organdie, percale, poplin, seersucker, voile, and velveteen.

Most of the wool we use comes from the soft fleecy hair that grows on the bodies of sheep. Wool was one of the first materials to be spun and woven into cloth. When early man saw the value of this material, he began to tame and raise sheep. For many purposes, even today, no other cloth is so satisfactory. Wool is especially important for garments used for warmth.

Sheep are raised in many countries, but the greatest amount of the world's supply comes from Australia and the United States. The cashmere goat of India, the angora goat of Asia Minor, and the llama and alpaca of South America yield types of wool that are used for special purposes.

Linen cloth is woven from the fibers of the flax plant. It may have been the first woven fabric ever to be used. Linen garments that were made thousands of years ago have been found in ancient Egyptian temples. For many centuries linen was considered the finest plant fabric. Although cotton eventually replaced flax as the cheapest and most abundant source of cloth, linen still remains the best and most durable fabric for many uses. Ireland long has been the center of the linen industry. Irish linen is world famous. Much of our best linen comes from Ireland.

Using electric sheep shears

According to legend, a Chinese princess was the first person to notice the work of the silkworm and to devise a way of turning the fine fibers of its cocoon into beautiful cloth. The discovery was kept from the rest of the world for hundreds of years. Then India and Japan learned the secret. The raising of silkworms is still an important industry in China, Japan and India.

Raw silk is shipped to other countries like the United States where it is processed by machinery. Much of that kept in the Orient is woven into cloth by hand.

In his great desire for more materials to feed his textile machines man has turned to the chemist to create fibers that rival those of the sheep, the cotton boll, the silkworm, and the flax plant. The man-made fibers are called synthetics. They are put together from a great variety of things such as air, water, wood, limestone, casein from skimmed milk, and coal.

One of the synthetics is rayon. Formerly known as "artificial silk" it is made from the cellulose of wood pulp or cotton linters, or a com-

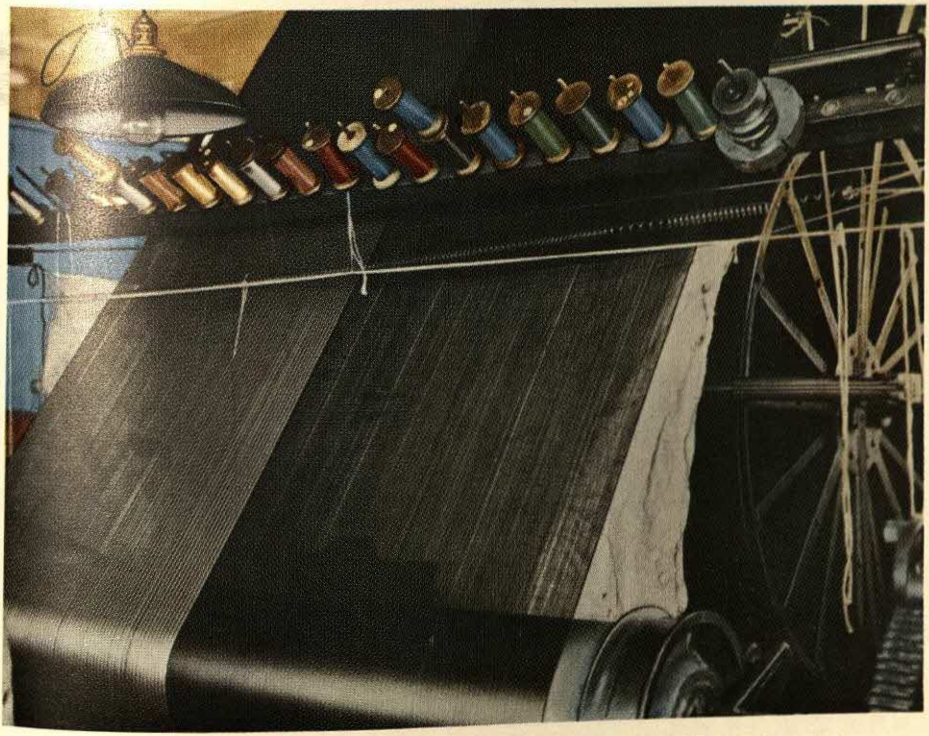
Primitive method of winding thread on reels to form little skeins of silk bination of both. Rayon now ranks second only to cotton in its importance as a textile material.

Nylon is another synthetic textile. It is made from four elements—carbon, hydrogen, nitrogen and oxygen—taken from air, coal and water. It first appeared when nylon hose were put on the market in 1940. Since then it has been used to make garments, parachutes, bristles for brushes, and other products.

A fireproof fabric is made by shredding asbestos rock. Cloth also is made by spinning molten glass into very fine fibers and combining them to make thread. Glass cloth sometimes is used to make curtains.

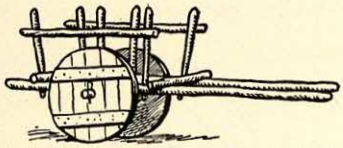
Rubber is another material that is widely used in outer garments wherever waterproof material is needed, especially in raincoats, and galoshes. Today there are a number of synthetic materials that do much of the work for which rubber was formerly considered necessary.

The whole story of clothes, textiles, and costumes is a very long one. It has its beginning in the far distant past, and new chapters are being added every day.

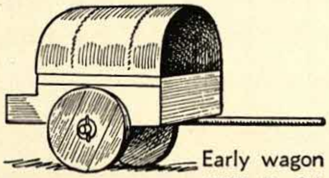


A warping machine, showing silk as it comes from the machine onto reels

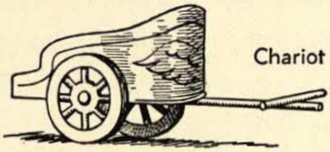
THE STORY OF TRANSPORTATION



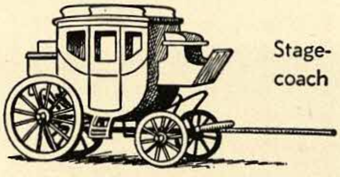
An ox cart



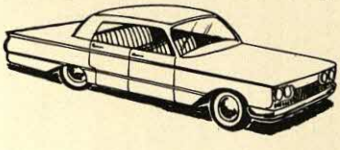
Early wagon (500 B. C.)



Chariot



Stage-coach



Automobile

Stages in development of wheel as seen in different forms of land travel

SELDOM a day goes by that something is not brought to our homes. It may be mail delivered by the letter-carrier, food brought by the grocer, or a newspaper delivered by a newsboy. And almost every day, nearly everybody rides somewhere for at least a short distance.

To make this possible, automobiles, trucks, buses, streetcars, trains, huge ocean-going vessels, and even the airliner which flies overhead have become as much a part of our everyday lives as clothes and food. All these forms of transportation, which make it possible to carry goods and people quickly and easily from one place to another, have come about in the last one hundred and fifty years.

From the very beginning, thousands of years ago, man found it necessary to move from place to place. If there was not enough food in one place, he wandered to another, taking along everything he could carry. After he learned to till the soil, he began to live in a permanent home which at first was a cave or a tree house or a house built on stilts in a shallow lake.

After that he carried or dragged home food and other supplies, which often must have required hours of work and great effort. So he tamed animals like the dog, the ox, the llama, the elephant, the reindeer, and the horse and trained them to carry his loads.

Then some one discovered that it was easier to roll a burden than to carry it. That discovery led to the development of the wheel, one of the most important things man ever invented. Without it, there could be no automobiles, steamships, trains, airplanes, watches, or hundreds of other things of which the wheel is a part.

No one ever will know what the first wheel was like. But it probably was no more than a thick slice of wood cut from the end of a log. Pegged with a similar one to a sort of axle which was fastened to the bottom of a platform or box, man had his first cart. To be sure, it was crude and awkward, but the cart did carry man and his goods faster, easier, and for greater distances.

Traveling by cart made roads necessary. Roads brought more people together. Exchange of goods and ideas brought new occupations and further improvements in man's living as well as in his transportation. Men became traders, merchants, blacksmiths, innkeepers, and inventors. Wagons, chariots, and stagecoaches were developed.

Long before the wheel, man had found that floating logs tied together into a raft would carry a load on water. By using poles or rough oars, the raft could be moved along the shores of a lake, or over calm stretches of a river.

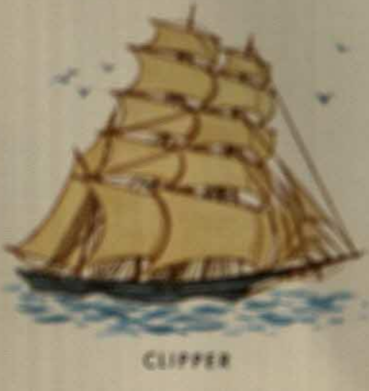
Then some one using fire and simple tools, hollowed out a log. Although the oldest in existence, this type of boat, known as the

People in many parts of the world still use the OX CART for land travel

VIKING GALLEON

ROMAN GALLEON

CARAVEL



CLIPPER

dugout, is used today in some parts of the world.

Later, in many places, primitive men learned to build boats made of light frames of wood or willow reeds. To cover them they used the best materials at hand—birchbark, skins, or asphalt. There were several different types, as for example, the Indian canoe, the Eskimo kayak, and the Welsh coracle.

As man improved in his boat building, the paddle followed the use of the pole. Later came the sail. But these developments did not take place at the same time in all parts of the world. Small Egyptian boats were sailing up and down the Nile when the Phoenicians were building boats rowed by tiers of galley slaves.

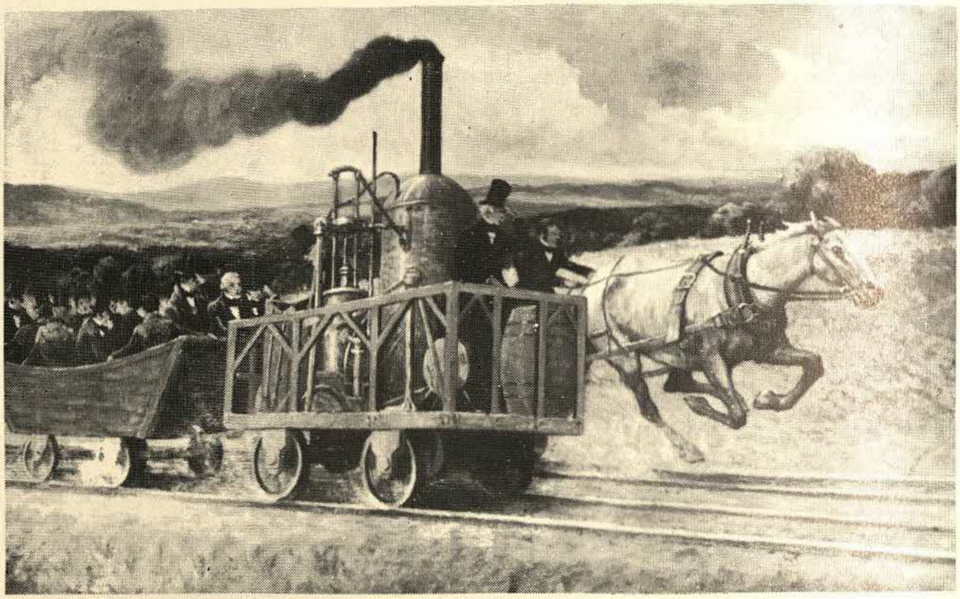
With the invention of the compass, ocean navigation became more exact, but it was left for Christopher Columbus to show that the new instrument could be used to guide ships across the ocean. In the mad scramble for the possession of America, European rulers demanded speedier ships. Better design and construction developed rapidly. One type followed another, galleon, frigate, and packet. Then came the clipper, the fastest sailing ship that ever has ridden the waves. Seen in all the world's ports the clipper was queen of the seas until the arrival of the steam engine.

James Watt was not the first person to experiment with steam as a source of power. But he was the first man to successfully put steam to work. His steam engine, invented in 1769, was largely responsible for starting our Machine Age. Its use and continual improvements lifted man from a slow to a fast-moving world.

In 1807 Robert Fulton steamed up the Hudson River in his boat, the Clermont. The steamship Savannah crossed the Atlantic in 1819. To be on the safe side, the ship was propelled by both sails and steam. In 1831 the Royal William made the first complete crossing of the Atlantic entirely under steam power. Within a few more years the famous Cunard Line was offering regular steamship service across the Atlantic.

One day in 1769 there appeared on the streets of Paris a queer three-wheeled carriage which had a copper kettle to move it instead of a horse. At least that is the way it appeared to the people who watched it puff along for a quarter of a mile at a speed of about three miles an hour. The watchers never had seen steam locked up and so they had no idea of its power. They laughed at the horseless carriage which really was a small steam engine. But it was that invention by Cugnot at which the Parisians scoffed and said would never amount to any-

This "horseless carriage" was made in 1889 and was propelled by a steam engine



The Tom Thumb once was defeated in a race by a horse-drawn car

thing that was the beginning of all power-driven transportation.

Years later, in 1825, in England, the first steam railroad began service with George Stephenson's famous locomotive, the Rocket, hauling carriages containing passengers and freight. The first regular rail line in the United States ran from Baltimore to Endicott's Mills, a distance of 13 miles. The locomotive used on that first run in 1830 was the Tom Thumb made by Peter Cooper.

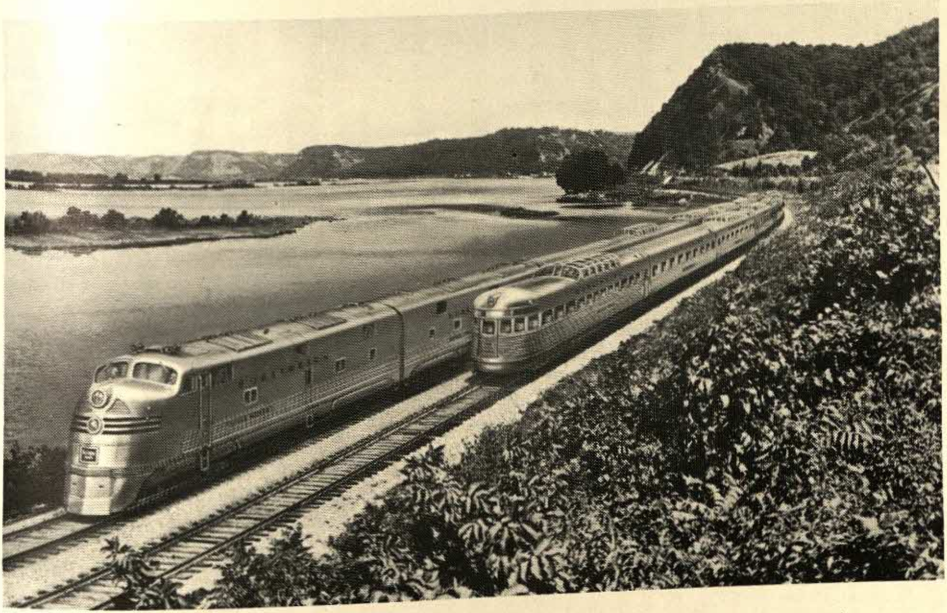
In 1869, less than 40 years later, two railroad companies joined their tracks, near Ogden, Utah, to form the first transcontinental rail line in the United States. With that, the settlement of the West was speeded up, and the nation was brought closer together.

As soon as man found a way to harness one source of power, he began to experiment with others. In 1885–6 Gottlieb Daimler, a German, produced the first internal combustion engine, an invention which changed chemical energy into mechanical energy by a series of controlled explosions. In the United States, Charles Duryea is credited with producing the first gasoline-driven horseless carriage in 1893. Soon Henry Ford and others began making automobiles and a new industry was under way.

The invention of the Diesel engine in 1900, and the construction of the first Diesel locomotive in 1925, opened a new era of speed and comfort in railway transportation. These powerful engines, a variation of the gasoline engine, burning fuel oil, rapidly haul trains long distances with little of the smoke and grime of the steam locomotive. Since 1934, when the first streamliners went into service, Diesel power has been increasingly used by railroads as well as by buslines, trucklines, and ocean vessels.

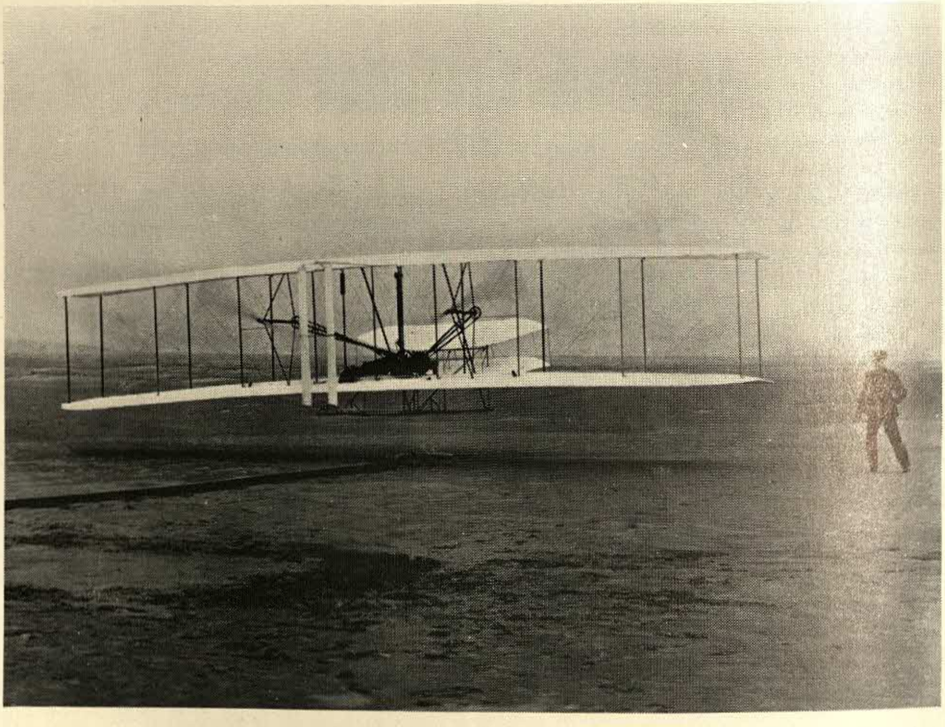
The first street railways in the world operated in New York City. The first streetcars were horse-drawn vehicles on rails. Meanwhile a few men had been experimenting with the idea of using electricity as a motive power. But it was not until the electric generator, then called a dynamo, was perfected that scientists began to give their attention to the development of the electric railway.

For ages man had watched the flight of birds and wished that he, too, might soar through the air. The famous artist, Leonardo da Vinci, actually made a pair of wings which were fashioned to move up and down by pedals worked by the feet. Although this and other efforts ended in failure, man continued to keep his eyes on the sky. His next efforts in flying took the form of balloons. In 1783, in France, there soared aloft a beautifully painted balloon, made of coarse cloth and



The Diesel locomotive opened a new era of speed and comfort in land travel covered with paper. Its owners, the Montgolfier brothers, had sent it up by filling the balloon with hot air and smoke. It came down as soon as the air in the bag cooled. Later the first hydrogen-filled balloon was sent up. Some men actually crossed the English channel in such a balloon. Other flights followed.

Next came the glider, a winged structure which used air currents to stay up and to travel. Samuel Langley put together a glider with a motor which flew across the Potomac River in 1896. Later he launched a similar plane, capable of carrying a man, but it was damaged during the take-off and the flight did not succeed.



The Kitty Hawk has been placed in the Smithsonian Institution, Washington, D. C.

Wilbur and Orville Wright began the age of heavier-than-air plane transportation. In 1903 they got their motor-driven plane into the air at Kitty Hawk, North Carolina. They made several short flights, the longest one for 59 seconds and at an altitude of 852 feet, and landed safely. By 1908 they had sold a model of their latest plane to the United States Government and, also, were showing the machine in

Europe. World interest was aroused. In 1910 Bleriot, a Frenchman, flew the English Channel, and shortly afterward Glenn Martin flew from New York to Albany.

The First World War advanced flying, as wars always advance many inventions. The armies realized the value of the airplane for reconnaissance, for bombing, and for carrying special supplies. Improvements were made, both in regular planes and in the dirigible, a lighter-than-air ship, invented in 1904 by Count Zeppelin. By the end of the war, many men of several nations were flying planes.

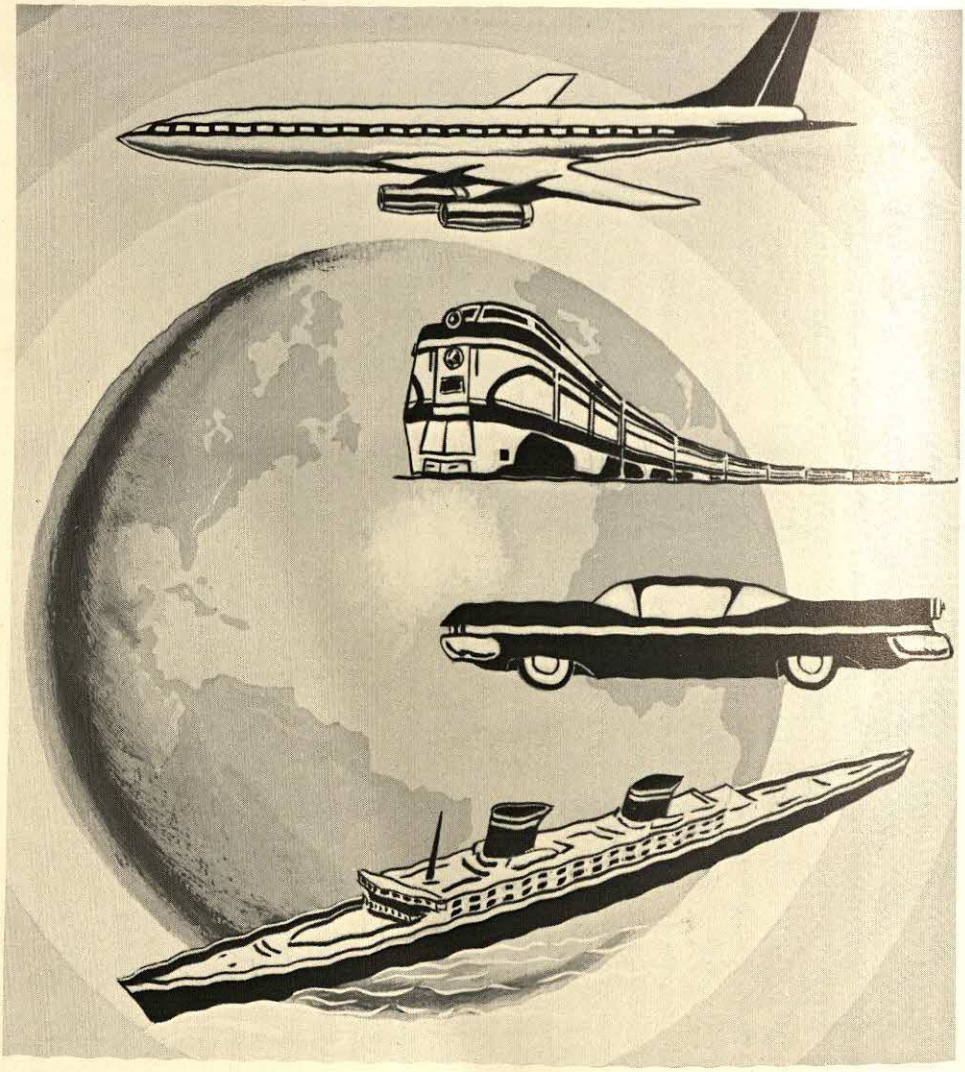
Such flights as those of Lieutenant Commander G. C. Reed, of the United States Navy, who flew from Newfoundland to England by way of the Azores; Richard Byrd, later Admiral, who flew over the North Pole; Alcock and Brown, who made the first flight from Ireland to Newfoundland; and Charles Lindbergh, who, in 1927, made the first non-stop flight from New York to Paris, greatly increased public interest.

Mail and passengers were being carried by plane between London and Paris in 1919. In the United States, the first air mail service was begun in 1918. Within five years a transcontinental route was put into operation. Passenger service grew slowly, but by 1930, airlines were spreading rapidly throughout the United States and many other countries.

Travel by jet is comfortable, pleasant and swift.

The Second World War brought many improvements. By 1942 airfields were common all over the world. Passengers and supplies were being flown across every continent and ocean. The globe shrank again as it had shrunk when the railroads were built.

Today man uses all of the oldest as well as the newest forms of transportation. He still rides horses and camels; he rows and sails small boats; he uses carts. But mostly he uses power-driven machines. In a cart it may take days to travel a short distance. By automobile he goes swiftly and with more comfort; a modern, Diesel-powered, streamlined train can take him from Chicago to the Pacific in less than 40 hours; an ocean liner can rush him from New York to Southampton in less than four days; while a plane will carry him half way around the world in 15 hours.



THE STORY OF COMMUNICATION

HEARING VOICES, Big Beaver, an Indian trapper, crept silently into the bushes that fringed the hilltop. Cautiously he peered into the clearing. There, only a few yards away, sat a group of white soldiers. As soon as the soldiers were on their way, Big Beaver made a fire and began sending up a series of short smoke-puffs. His people several miles away, seeing them, immediately knew that an enemy was approaching their village.

Big Beaver's way of sending a message to his people was a common method of communication among the Indians of North America. Each tribe had its own code of signals. The smoke signals were sent from a high place, clear of trees, and from a fire built of damp grass or cedar boughs. The short puffs were made by covering and uncovering the fire with a blanket.

The early white settlers of America quickly learned what such signals meant. They, also, learned to read other messages, such as those sent at night by means of burning arrows.

Smoke and fire signals have been used by many people throughout the world. Some world events have been announced by beacon fires. Blazing fires that could be seen from hilltop to hilltop told the Greeks that King Agamemnon had taken Troy. In some parts of England memorials have been erected on the beacon hills where in 1588 fires burned to warn the people of the approach of the dreaded Spanish Armada.

The Greeks also communicated with one another by flashing their polished shields in the sunlight. The ancient Egyptians and Persians used mirrors to flash signals.

Other early forms of communication were based on man's ability to hear. One such way of spreading news was by shouting it from one man to another, each crier being stationed on a hilltop within hearing distance of the other. When Pizarro came to Peru he found wooden towers built on the mountaintops to shelter the Peruvian news criers. In colonial times it was a common practice to have a town crier shouting the time and the news on his rounds through the town.

Tapping out messages on a drum is one of the oldest methods of communication. Some African natives and South Sea Islanders still use it to relay messages from one village to the next. The first white explorers and missionaries were unable to understand how news of their coming was known long before they arrived at a native village. Later they learned that each village and tribe had its own drum station and special drummers.

From early times messages have been carried by runners. One of the greatest foot messengers was the Greek youth namd Pheidippides. He was able to run 150 miles in two days and nights.

The Romans established relay stations, with food and horses for their government riders, on the five great highways leading to Rome. Whenever the routes crossed rivers or seas, boats manned by excellent rowers were on hand to take the couriers swiftly on their way. Often the Roman armies had carrier pigeons, which could be taken by messengers into enemy country and sent back with important dispatches.

During his travels, Marco Polo found that the people of northern China had a post system whereby foot messengers, running in three-mile relays, could carry a message 100 miles in a day. Each runner wore a belt of bells in order to announce his approach in time for another runner to be ready to carry the message to the next station.

It was a great day in 1673 when the first mail carrier in colonial America set out from New York City for Boston. His route of travel was chiefly over Indian trails in the wilderness. Within a few years post riders were carrying mail from Maine to Georgia. As roads were improved, stages were used. Many of those roads over which the mail

ROD TAENZER
C

Man uses many ways to communicate with others. An important one is printing. It is a convenient way of sending a message to vast numbers of people. These messages usually are printed in books, magazines, or newspapers.

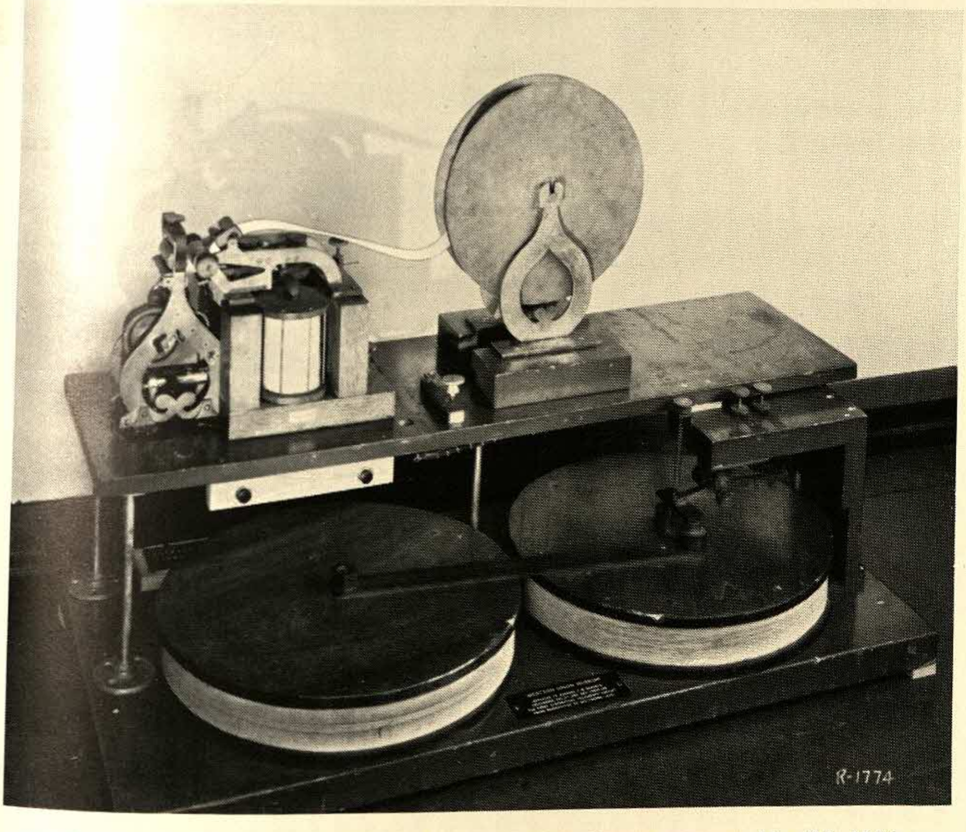
The early printing presses were very crude affairs, as can be seen by looking at this picture of Benjamin Franklin at work in his print shop.

When Franklin, one of the greatest Americans, was a little boy, he was so fond of books that he wanted to know how to make them. He went to work in his brother's print shop in Boston. There he learned to set type and to run the "hand press." Later in Philadelphia, when he was about twenty-one, he owned the largest printing business in America. There he printed *Poor Richard's Almanac*, a sort of magazine containing his short wise sayings, many of which are well-known today.

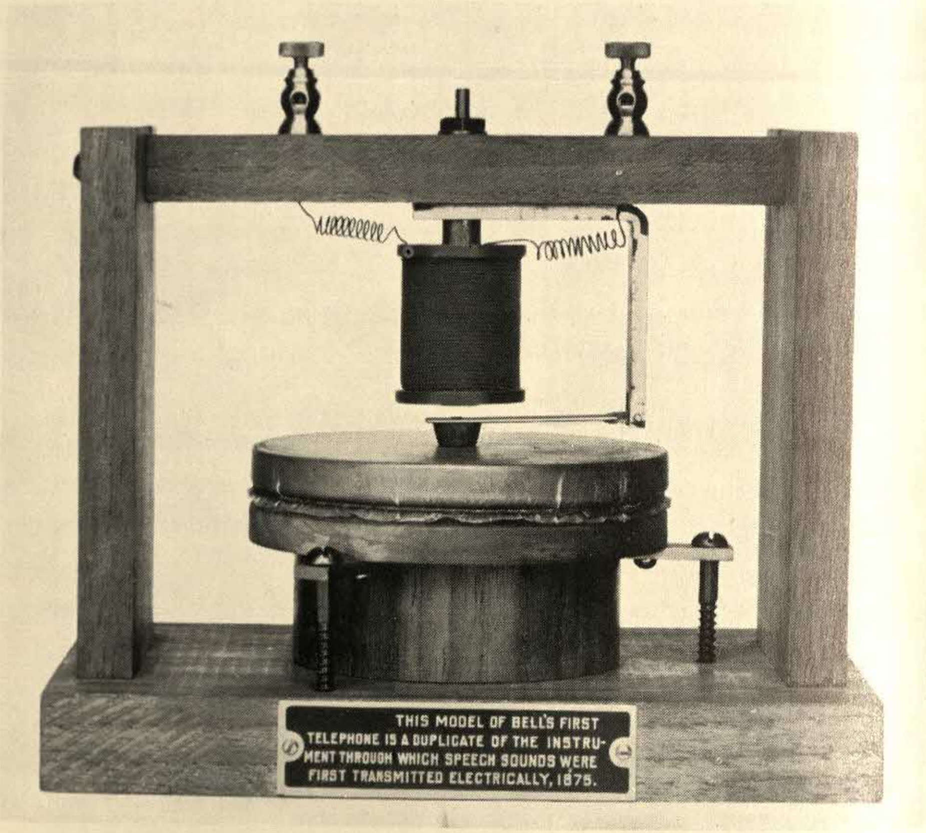
was carried are still referred to as "the old post roads."

Of all the early ways of carrying mail in the United States, none was more exciting than the Pony Express. That carrier service started at St. Louis, Missouri, and ended at Sacramento, California. Only the swiftest horses were used on the route. They were changed every ten or twenty miles. As the Pony Express messenger neared a station, the man in charge of it would have a fresh horse ready. The rider was allowed only two minutes in which to change horses. Buffalo Bill was only fifteen years old when he rode the Pony Express 380 miles in thirty-six hours.

No great improvements in the methods of communication came until Samuel F. B. Morse, a New York portrait painter, invented the telegraph, an electrical instrument by which it is possible to send messages almost instantly over wires. On May 24, 1844, the famous message "What hath God wrought" was sent from the Capitol at Washington



The telegraph instrument used by Morse to send his famous message, May 24, 1844


THIS MODEL OF BELL'S FIRST TELEPHONE IS A DUPLICATE OF THE INSTRUMENT THROUGH WHICH SPEECH SOUNDS WERE FIRST TRANSMITTED ELECTRICALLY, 1875.

The first telephone invented in 1875 by Alexander Graham Bell

and successfully received in Baltimore. That message clicked off in a series of dots and dashes, known as the Morse Code, started a new era in communication.

At first only one message at a time could be sent over a single wire. Today it is possible to send a number of messages over the same wire at the same time. In the United States alone over 2,000,000 miles of telegraph wires span the country.

By the year 1858, Cyrus W. Field had succeeded in laying a submarine telegraph line, or cable, across the Atlantic Ocean to Europe. Now many cables spanning the various oceans and seas make it possible for people to send cablegrams to distant parts of the world.

In a small Boston workshop on the tenth of March 1876, two men were deeply absorbed in work, as they had been for many months. On that particular day, one man in the attic spoke into a queer looking device, which he called a transmitter, saying, "Mr. Watson, please come here. I want you."

In a couple of minutes Mr. Watson dashed up from the basement shouting, "Mr. Bell, I heard you."

For a moment Alexander Graham Bell was speechless. At last, after years of toil and hardship, his dream of a telephone had come true.

Later that year Mr. Bell gave a public demonstration of the telephone at an exposition in Philadelphia celebrating the one hundredth anniversary of the Declaration of Independence. Even after that, it took some time to convince people that it was possible to talk into a transmitter at one end of a wire, and to be able to hear the same words through a receiver attached to the other end. Today in the United States there are fifteen telephones for every 100 people.

Greater wonders in communication were on the way. In 1895 a young Italian, Guglielmo Marconi, succeeded in sending signals by electric waves without the use of wires. His invention was none other than the wireless telegraph.

The knowledge that scientists and inventors had gathered from the inventions of the telegraph, telephone, and wireless telegraph spurred them on to discover a way to send telephone messages without wires. In time came the radio, that wonderful instrument which permits us by the snapping of a switch to fill our homes with music, or to listen to someone speaking to a world-wide audience.

The radio is a wireless telephone. Its wonder lies largely in a little glass bulb, called the audion tube, which was developed by a young wireless fan by the name of Lee De Forest. It was De Forest's invention of the audion tube that opened the way to modern radio, sound motion pictures, radar, and no doubt other miracles to come.

In the use of radar, waves are reflected back to the sender when they strike objects. Not only that, but the shape, size, and distance of the object that reflects the radar waves can be determined. For instance, radar enables airplane pilots to know whether a ship, or a mountain top, or another airplane is near, even when the object cannot be seen with the eye.

As soon as men learned to transmit speech and music through space, they began to search for a way to send pictures in somewhat the same way. The first telephotograph was sent over a wire in 1924. At the present time many newspapers use this method for securing pictures of important people and events promptly from distant parts of the country. Pictures, also, are sent by radio.

Not content to just send pictures through the air, scientists began trying to transmit moving pictures for people to enjoy in their homes. Out of their efforts came the invention of television, which name means "to see far off." Television transmits both the sound and the picture at the same moment.

We can now sit in our living rooms and actually see things that are happening in countries as far away as India. Thus television has become one of the most vital means of communication, because it has brought all the peoples of the world closer together.

Swift and efficient communication is an important part of our everyday lives. Yet in many parts of the world there are primitive people who would not believe that it is possible to talk directly to a person on the other side of the world. Modern science has produced in the field of communication instruments much more wonderful than any magic.

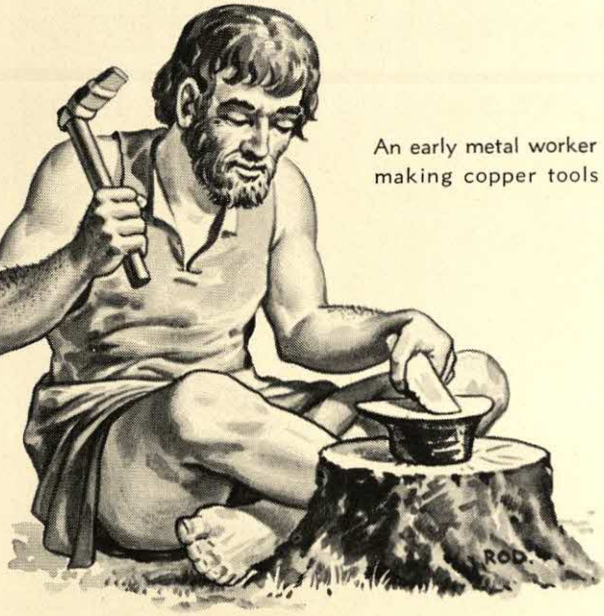
Television transmits both sound and picture at the same moment

METALS AND MACHINERY

EARLY prehistoric man had no tools. He was completely dependent upon his hands to obtain his daily needs. Slowly and in simple ways he began to take the things which he found near him and turn them to his uses.

Ever on a prowl for food, early man probably first used sticks and stones to aid him in capturing some of the smaller animals. While such weapons were very crude, they helped to start him on his way to become master of the world.

Archaeologists and others digging in the earth have turned up rough weapons and tools of stone that must have been used thousands of years ago. Some of them are so jagged and uneven that it is difficult to know whether they were chipped by man for some special purpose, or just happened to be in that form. Others show such fine workmanship that it is easily seen that their makers knew how to shape and polish stones into smooth hatchets, spears, and other implements. From all those various specimens, scientific men have been able to chart the advances man made in his way of living after he learned how to make tools and weapons. To the thousands of years in which he made them of stone they have given the name Stone Age.



An early metal worker making copper tools

It is thought that copper was the first metal discovered and used by man. Pure copper can be quite readily hammered into any shape. In some parts of the world the metal is found in an almost pure state. Some of the first European explorers who came to America found the Indians living near Lake Superior picking up pieces of copper and pounding them into useful implements with their stone hammers.

Still man never would have made much progress with metals, even with copper, if he had not learned to smelt them, that is, to melt them from their ores by fire.

In fact, early man took some of his greatest steps forward when he began to discover the uses of fire. At first fire gave him warmth and light. Then he learned to use it to cook food. And sometime later he learned to use it in working with metals.

It was found that heated copper could be hammered into shape easier than the cold metal. Then someone discovered that objects could be made by melting the copper and pouring it into stone molds. After it cooled and hardened, the metal could be lifted out fully shaped according to the mold. The Egyptians were making articles of copper 5000 years before Christ.

However, there was one serious drawback to the use of copper. The metal did not have enough hardness and strength for strong tools and weapons. The edges of knives and axes made from it dulled very quickly. Then one day somebody accidentally smelted a mixture of the ores of copper and tin. He found that the new mixture when cooled produced a very much harder and stronger metal than any that had been made before. Such a mixture of copper and tin is bronze.

That was perhaps the first mixture of metals to be made. Ever since man learned how to make bronze, he has been trying to mix all kinds of metals in an effort to create stronger and more durable tools. Any mixture of metals is called an alloy.

Scientists speak of the many hundreds of years that man used bronze to make his tools and weapons as the Bronze Age. In that period the Babylonians, Egyptians, and Grecians built great cities, while the Phoenicians became the world's great sailors. Part of the cargoes carried by the Phoenicians was tin ore from Cornwall, England, which was mixed with the copper of the Mediterranean countries.

Iron became known during the Bronze Age, but it remained a rare metal until it was discovered by the ancient Hittite people in their mountains of Asia Minor. Even then the use of iron proceeded slowly. In order to smelt the iron ore, a great deal of heat was needed, which in turn demanded much fuel and a special kind of furnace. However, when it was seen that for many purposes iron was superior to alloys of copper, improved ways were found for smelting and working it.

Iron-making is an ancient craft among certain tribesmen in Africa. From them one may get an idea of how the earliest iron-makers must have made iron. They place the iron ore in a shallow hole, lined

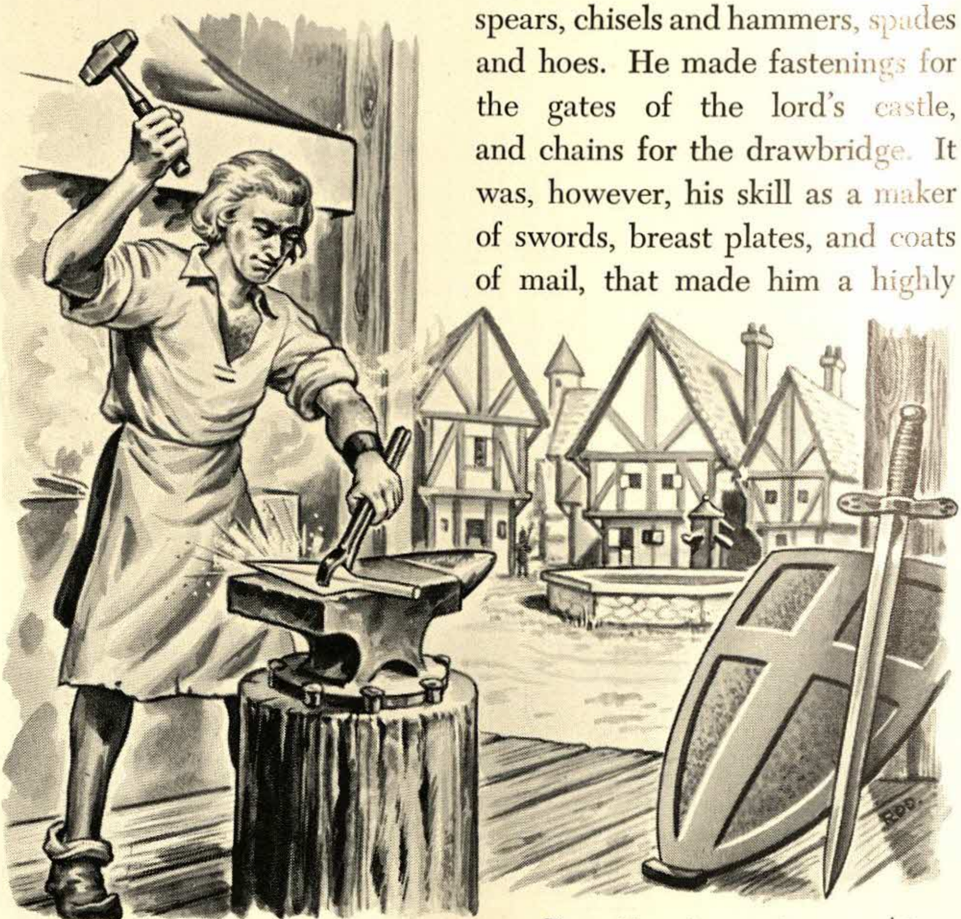
Smelting iron ore in an early forge

with clay. Into this fire-pit they add charcoal and then start a fire. More layers of ore and charcoal are added. To produce a very hot fire to melt the ore, the iron-worker pumps blasts of air into the pit by bellows.

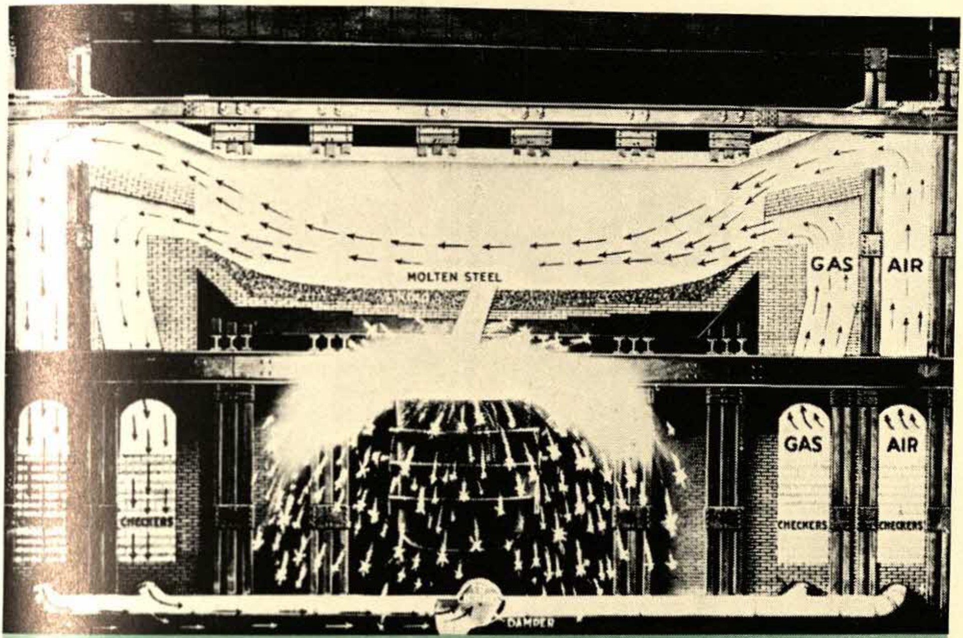
The bellows, made of animal skins, are worked with sticks. By means of the bellows the iron worker is able to make a fire hot enough to reduce the iron and separate it from the rest of the ore. This method, however, does not melt it and it cannot be poured into a mold. It can only be hammered or worked into shape while still hot.

Worked or hammered iron is called wrought iron. The man who hammers the iron into shape is called a smith.

The ancient Greeks and Romans became expert smiths. So did the English and Normans. The smith was a very important person in Anglo-Saxon times. He made nails and spears, chisels and hammers, spades and hoes. He made fastenings for the gates of the lord's castle, and chains for the drawbridge. It was, however, his skill as a maker of swords, breast plates, and coats of mail, that made him a highly



The smith, an important man was he



Any kind of iron can be used to make steel in an open hearth furnace

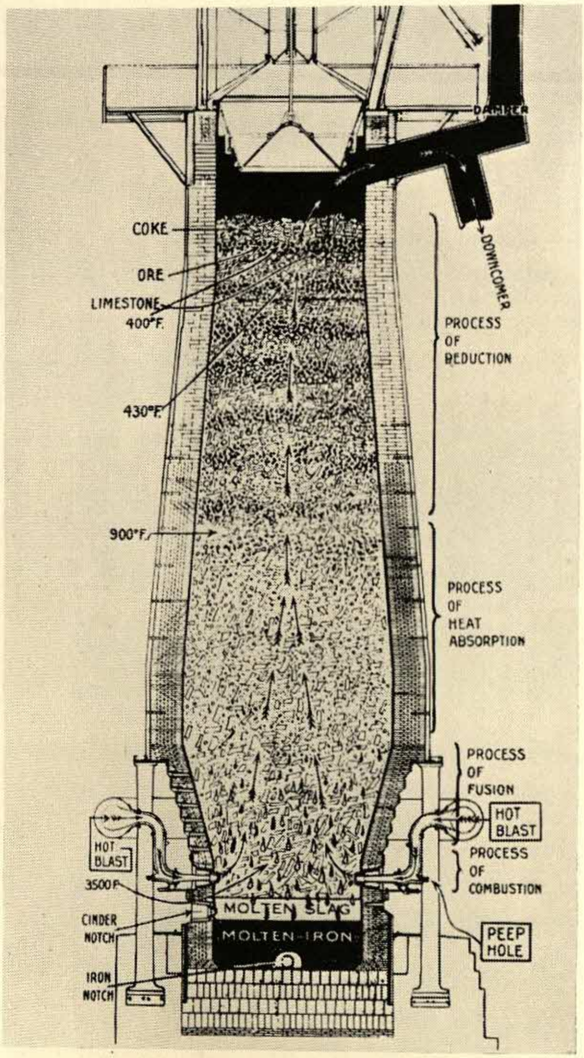
respected person, and permitted him to sit in the great hall with the lord and lady of the castle.

For many centuries Europeans continued to use iron for their implements of war. Then they met the Moors. The Moors were clad in shining armor and fought with glistening swords, sharper than any the Europeans had ever seen. The swords were made in Damascus of a material called steel.

Although no one knows how the Moors discovered steel, we do know how they made it. They allowed some of the carbon from the burning charcoal to mix with the iron. Then they hammered the hot metal into shape and immersed it in cold water. By so doing they were able to produce a finely tempered steel. Damascus steel is still famous.

Today steel is our most widely-used material of metal. It forms the framework of bridges and skyscrapers; it is the main material used in most tools and machines. It is used for many articles large and small, from steel rails to sewing needles.

It took many centuries for man to learn how to make fires hot enough and furnaces big enough to melt large quantities of iron. The fire-pit or open furnace was wasteful. Using it, two workers



A cross-section of a blast furnace

could produce only a few pounds of iron in a day. Then some person built a furnace known as the Catalan forge, an enclosed cone-shaped structure, of brick or stone. Its construction prevented the loss of heat which made the fire pit or open furnace so expensive to operate.

As more and more Catalan forges were built, more fuel was needed. Also a search was made for better fuel. Coal was tried, but ordinary coal did not produce enough heat to melt the iron. Finally it was discovered that by baking soft coal for several hours in a hot oven, a fuel was produced that would give off a great heat. The new fuel was called coke. To this day coke is still widely used in smelting iron and making steel.

Although the Chinese knew how to make cast iron, it was not until the thirteenth century when the Germans invented the blast furnace that cast iron was given to the world. Before that, outside of China, all the iron had been wrought iron.

In making cast iron, the furnace must be hot enough to melt the iron completely. Then it usually is poured into molds shaped so that the iron hardens into bars. These bars are called pigs, and the iron cast in this form is known as pig iron. Pig iron is the raw material from which steel and other forms of iron are made.

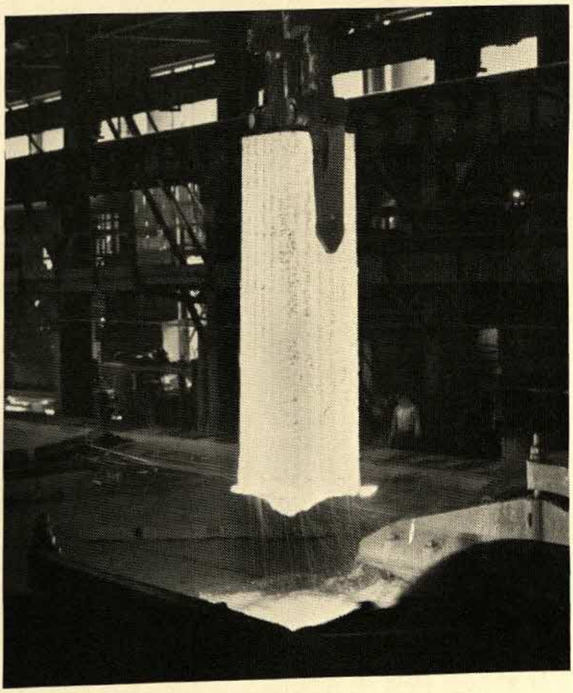
The English, who became great manufacturers of iron and steel, learned how to build blast furnaces from the Germans. As larger and better furnaces were developed, power was used to drive the bellows.

Modern blast furnaces are huge towers of brick enclosed in a heavy jacket of steel. They are filled with iron ore, coke, and limestone in the correct proportion. The oxygen in the ore is driven off by the burning coke while most of the impurities in the ore combine with the limestone to form a scum, called slag. The slag being lighter than the molten metal, collects on top.

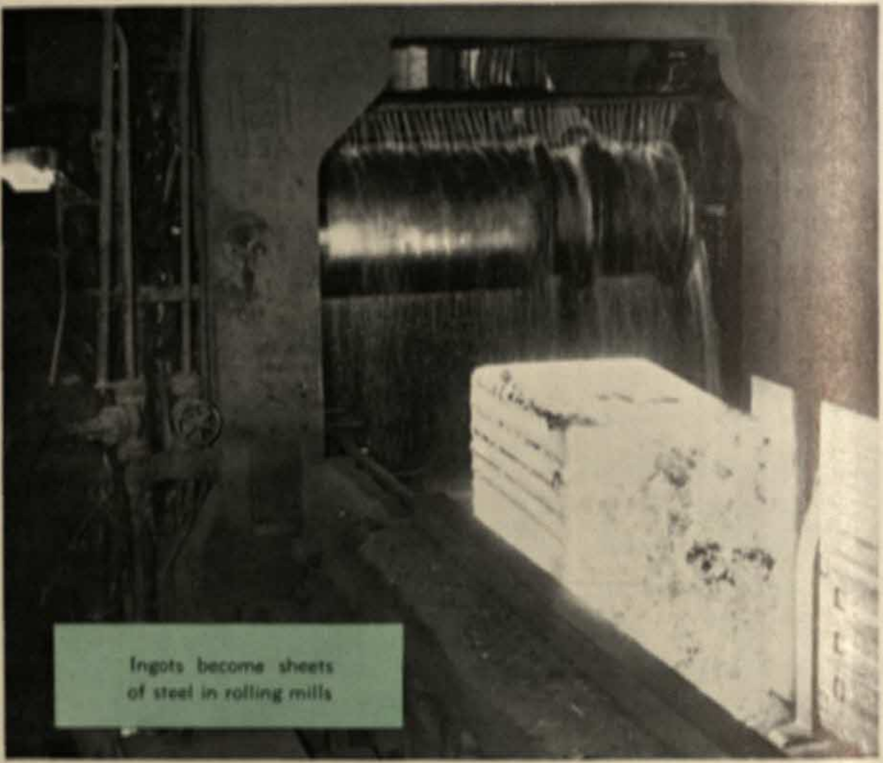
However, the pig iron produced by the blast furnace still needs further refining for most of the purposes for which the metal is used. It still contains some impurities. Also by adding small amounts of other elements, various alloys of iron are produced which serve special needs.

For centuries removing the impurities from the iron had made steel-making a very expensive process. Man tried one method, then another to find a cheaper way to make steel. It was Sir Henry Bessemer of England who discovered a process that still is quite frequently used.

An immense container called a Bessemer converter, with an open top holds the molten metal while a stream of air is forced through it to burn away the impurities. Then the white-hot steel is poured into a ladle, large enough to hold many tons of the liquid at one time. From the ladle the metal is run off into tall molds to form steel ingots.



Steel ingots formed from molten iron



Ingots become sheets of steel in rolling mills

Next the rolling mill takes the ingots while still hot and runs them between heavy steel rollers. Here the steel is made into sheets from which may be shaped any of the thousands of forms in which it may be wanted.

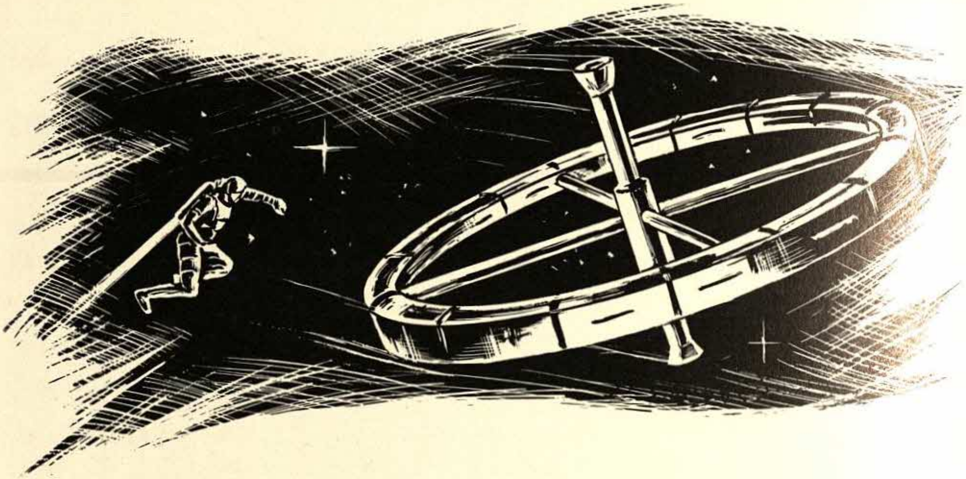
Electric power is used in most steel mills. Giant cranes pick up the ladles of molten metal and carry them to the ingot molds. Many modern steel plants use electric furnaces.

Without the production of great quantities of steel the kind of world we live in would be impossible. In modern steel laboratories scientists are constantly trying to find ways to make new and better alloys. Then, too, while iron is the most widely used metal, other metals such as copper, zinc, tin, lead, nickel, or their alloys hold important places in filling special needs in industry.

We live today in an age of machines. This modern age started with the invention of spinning and weaving machines and James Watt's invention of the steam engine which occurred during the latter part of the eighteenth century. One machine demanded or suggested another. With the use of steam, and later, other forms of power such as the internal combustion engine and electricity, it was no longer necessary to operate the machines by hand. Bigger and bigger machines were built, often combining several operations into one.

We have come a long way indeed from the use of the crude tools and weapons of our early ancestors. The story of that progress really goes back to the time when man found metals buried in the rocks of the earth and started to find ways of turning them to his uses.

An ore boat ready to embark with its cargo for the steel mills



SPACE EXPLORATION

THE CHALLENGE OF SPACE

WHEN was the first time a man looked up at the moon and stars and wondered about them and gave them names? When did man first dream of traveling to distant planets? We do not know, but today there are artificial moons in the sky called satellites, and man has placed them there. Man has begun to make the age-old dream of space travel come true.

What is space? Space is an immense, boundless area in which the stars and all the planets move. In space, too, there are tiny planets called planetoids or asteroids. There are rocky, metallic bodies called meteors and meteorites. There are magnetic forces and various kinds of piercing rays. In the huge black emptiness between these objects there is no air, no heat, no sound.

Space begins at the outermost edge of the blanket of air that surrounds the earth—the blanket of air called the atmosphere. This is about 120 miles above sea level. Beyond this, space goes on and on.

Why has it taken men thousands of years to begin the exploration of space?

In the beginning of this book, in the section on Earth and Sky, you read about the force of gravity.

The force of gravity holds us to earth. No matter how high you toss a ball into the air, it always comes down. The earth pulls it back. The earth pulls everything toward it—people and buildings, mountains and seas, and even the air. To travel into space, we must break away from the earth's pull.

How can we do this? Scientists discovered that as an object moves farther and farther away from earth, the pull of the earth's gravity becomes weaker and weaker. If an object can fly fast enough, it can escape from the earth's gravity. To do this, it must fly at a speed of about 25,000 miles an hour. This speed is called escape speed or *escape velocity.*

The fastest jet plane cannot fly that fast. Even if it could, it still could not travel into space. A plane needs air to hold it up and keep the fuel in its engines burning. There is no air in space.

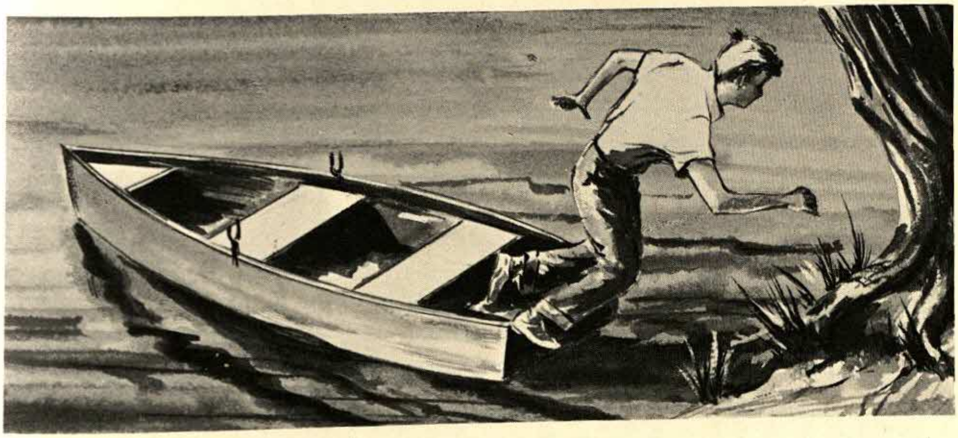
A rocket can travel into space. To understand why, we must understand how a rocket works.

A rocket works on a law of motion discovered many years ago by an English scientist, Isaac Newton. This law says: every action has an equal reaction in the opposite direction.

Suppose a boy is in a boat a few feet away from shore. The boy stands on the stern of the boat and jumps toward the land. As he jumps, the boat moves away from him.

The boy's jump forward is the action. The boat's movement in the opposite direction is the reaction.

The force that moves a rocket works in the same way.



ROCKETS AWAY!

SOME rocket engines are simple. Others are complicated. But all rockets work in about the same way.

A simple rocket engine has a tube that is almost full of solid fuel. The front end of the tube is closed. The back end is open to form the hole, or nozzle, of the rocket.

When the fuel in the tube is set on fire, it forms hot gases which pass out through the nozzle of the rocket.

At the front end of the rocket tube is a sharp, pointed cone that enables the rocket to cut swiftly through air.

How does a rocket work? It uses action and reaction. Here is another example.

When you blow into a balloon you force air into it. This air presses equally on all sides of the balloon.

When you release the balloon, the stem opens and some of the air rushes out. Now less air is pressing on the bottom of the balloon.

The air pressure inside is no longer equal on all sides. There is more air pressing at the top of the balloon than at the bottom, and this pressure forces the balloon to rise.

The rush of air from the stem at the bottom of the balloon is the action. The upward rise of the balloon is the reaction.

When the fuel inside a rocket tube burns, and forms hot gases, these gases push against all sides of the tube.

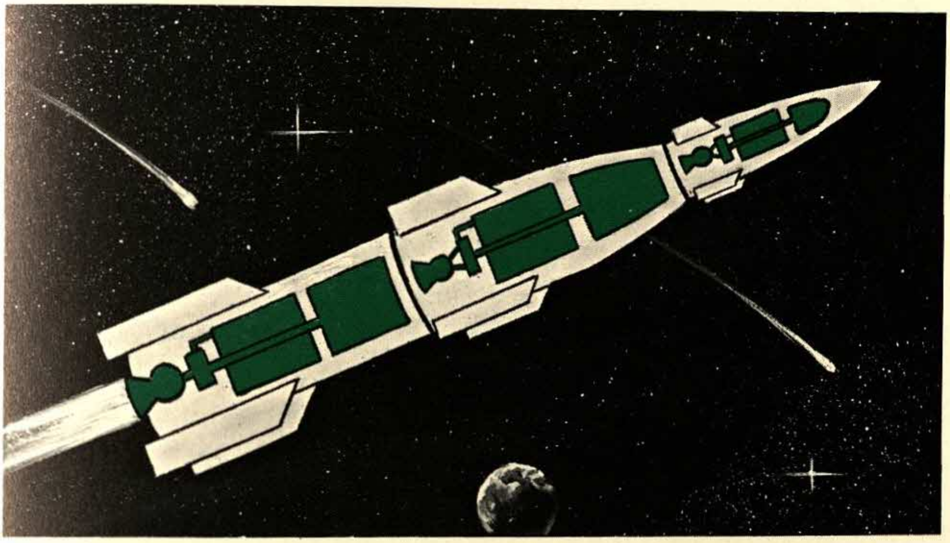
Some of these gases shoot backward from the hole in the rear of the rocket. This is the action. The rocket shoots forward. This is the reaction.

The push of the burning gases against the sides of the rocket tube is called *thrust*. The more thrust a rocket engine has and the longer the thrust can be applied, the faster a rocket can go.

A rocket has thrust only while the fuel in its engine is burning. The more fuel a rocket carries, the longer it can increase speed, or accelerate.

Simple rocket engines use solid fuel. Complicated rockets usually use liquid fuel. Some rockets may use both solid and liquid fuels.

Every kind of rocket fuel needs oxygen to make it burn.



Most of the space in this three-stage rocket is used to store fuel

Space rockets carry oxygen with them in huge tanks. The oxygen is squeezed, or compressed, until it becomes liquid. Then the liquid oxygen is injected, a little at a time, into the burning chamber where it is mixed with the fuel to produce a very hot flame.

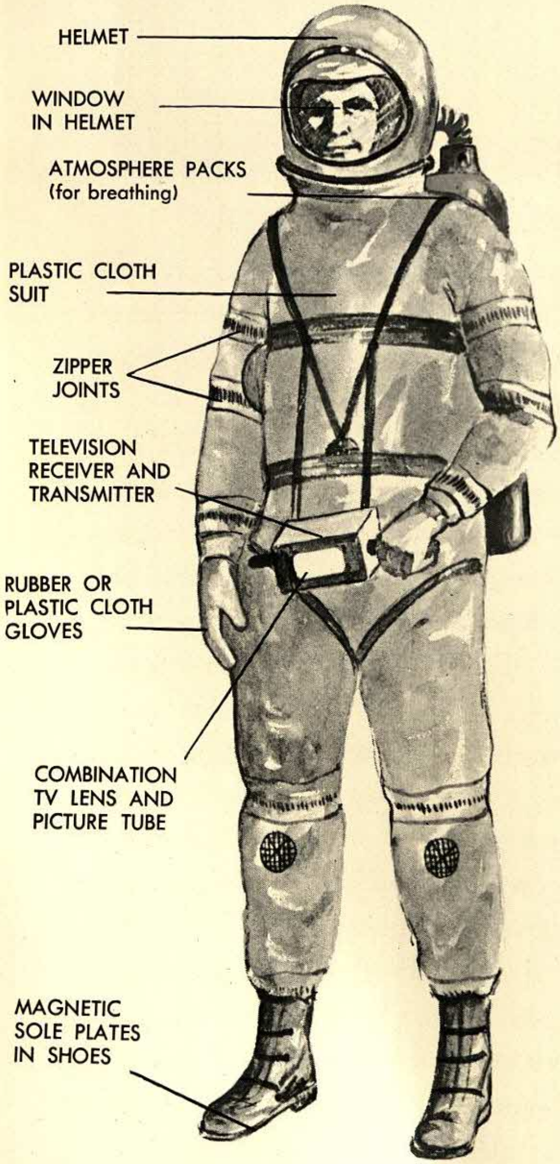
Most of the interior of the present-day rocket is used to store its large supply of fuel. This is because the fuel is consumed very quickly. To conserve the fuel, rocket engines are used only to escape the earth's atmosphere at the beginning of a flight and to land at their destination. During most of the flight the rocket coasts in space. The engines may also be turned on to change the course of a rocket's flight.

When a rocket uses up its fuel, the fuel compartment is no longer of use to it. It becomes dead weight. That is why space rockets are usually built in two, three, or more sections, or *stages.* Each stage has its own engines. When the stage at the tail of the rocket uses up all its fuel, it drops off. Then the next stage uses its fuel to speed the rocket on its way. During this time the rocket's speed is increasing, because thrust is building up. When the fuel in the second stage is gone, it drops off. Finally only the last stage of the rocket is zooming into space. This stage carries the important part of the rocket—the payload. The rocket's payload is its cargo, which may be instruments or animals or it may be a man.

MAN IN THE WORLD OF SPACE

SOMEDAY you may be one of your country's spacemen or spacewomen. Let's suppose that your rocket is ready.

Its course has been carefully planned and timed so that its path, or *orbit*, will cross the orbit of the planet it is heading for at exactly the right second.


HELMET
WINDOW IN HELMET
ATMOSPHERE PACKS (for breathing)
PLASTIC CLOTH SUIT
ZIPPER JOINTS
TELEVISION RECEIVER AND TRANSMITTER
RUBBER OR PLASTIC CLOTH GLOVES
COMBINATION TV LENS AND PICTURE TUBE
MAGNETIC SOLE PLATES IN SHOES

You are inside the rocket cabin, which is sealed tight so no air can escape from it into space.

Remember, there is no air in space. The rocket must carry the oxygen you need to breathe.

It also must carry chemicals to keep the air inside the rocket fresh.

As the rocket blasts off, you are thrown hard against the pad to which you are strapped.

A great weight seems to press against you as the rocket zooms into the sky.

Great speed produces a force much like gravity. This is called *g-force.*

If the amount of speed, or acceleration, goes as high as 7 g, you will feel seven times as heavy as you do on earth.

But soon the rocket engines cut off. The great weight is gone. The rocket is coasting in free flight, or free fall.

You and the rocket and everything inside it are weightless. If you were not fastened to your pad, you would float about the cabin.

As you unstrap yourself from your pad, you move very carefully. If you took a quick step you might fly up to the ceiling. You are glad that there are magnets on the soles of your space suit to help you stay on the cabin floor.

Eating is a problem in free fall, too. You cannot cook in open pots because the food would float up and scatter around the space ship galley. Much of your food will be prepared on earth and kept in freezing compartments until needed. Milk and water and other liquids will not pour because there is no gravity to pull them down into your glass. Liquids and much of your other food will be in squeezable, plastic bottles and you will sip them through a straw.

When you go to bed you will strap yourself to your bunk. If you did not, and turned over in your sleep, you would float about the cabin, bumping into walls or into your crew mates.

It may seem strange at first to live and work in free fall. You may even have a feeling much like seasickness. But scientists have found that most people adjust to free fall quickly

Although people can adjust to free fall, it would be uncomfortable to live and work in it for long periods of time. That is why scientists have designed manned space stations that have a kind of gravity.

There are many shapes for these space stations. One of the best-known shapes is a huge wheel in the sky. This space station will spin endlessly. Thus, using centrifugal force, it will pull all things in it toward its outer rim, just as gravity pulls things toward earth.

Perhaps someday you will land on a space station to have your rocket ship refueled or to jump off in another space ship for a trip to the far planets or the moon. Some space stations will be giant laboratories where scientists observe, study, and photograph the earth and stars and the mysteries that lie in space.

The exploration of the far reaches of space has just begun. Yet we have already discovered some of the secrets that lie beyond the earth's atmosphere. What will space explorers of the future discover? You may be one of these space explorers!

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